INDEX TO

The Boiler Maker

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JANUARY TO DECEMBER, 1909

THE BOILER MAKER,
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INDEX.

NOTE.—Illustrated articles are marked with an (*) asterisk before the page number.

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THE BOILER MAKER

JANUARY, 1909

THE UNION BOILER WORKS.

The plant of the Union Boiler & Manufacturing Company, of Lebanon, Pa., is an old-established one, having been started by F. J. Obert about forty years ago as a branch of his Reading shop, on account of the great demand for work in and about Lebanon at the various blast furnaces. The present corporation was formed in 1896, and has been doing such a large business in blast furnace work, buoy work for the United States government, boilers, stacks and tank work, and also structural work for use, not only all over the United States, but in Canada and foreign countries as well, that it has been necessary to enlarge and remodel the shops. The present officers of the company are: Robert Mitchell, president, Philadelphia; John J. Hursh, vice-president, Newville, Pa.; H. T. Richards, secretary, Lebanon; John Hunsicker, treasurer, Lebanon; William A. School, superintendent, Lebanon.

As shown in the plan, Fig. 4, the main shop is 202 feet long and 58 feet wide. At the west end is a 29-foot bay, in which is located the blacksmith and flanging department, and a bay 74 feet long by 46 feet wide used as a store room. The east bay, which is 40 feet wide and about 100 feet long, comprises the laying out, punch, roll and shear department. At this end of the shop the power plant, tool room and general offices are located.

The power plant consists of one 80-horsepower, horizontal, return tubular boiler, built by the company; a 25-horsepower Atlas engine, and a 35-horsepower Ingersoll-Sargeant air compressor, with a capacity of 200 cubic feet of air per minute. The engine is belt-connected to a line of overhead shafting, extending through the center of the punch, roll and shear department. All the machine tools are, therefore, driven from this shaft without an intermediate electric drive.

FIG. 1.—VIEW OF MAIN SHOP LOOKING WEST.

The arrangement of the machine tools in this part of the shop is clearly shown in Fig. 3, which is a view of the east bay, looking towards the office. At the left of this photograph, just behind the laying-out bench, is a Hilles & Jones horizontal punch and a Hilles & Jones No. 4 cold saw. At the end of the bay is a large 42-inch gap punch, built by Hilles & Jones Company, and in front of this is a combined punch and shear with 23-inch gap. At the right of the punches is a drill press, built by the Fosdick Machine Tool Company. Next to this is a small punch for light plate, a Lennox rotary bevel shear, and a set of 6-foot bending rolls with a capacity for bending plates up to ½ inch thickness. The bending rolls for heavy work are shown in Fig. 1, which is a view of the main shop looking west. These rolls are 10 feet long between housings, and were built by the Lebanon Manufacturing Company.

At the west end of the main part of the shop is a 75-ton, 10-foot 6-inch gap hydraulic riveter with pump and accumulator. The work is handled at this machine by a 5-ton electric traveling crane, which has a span of 25 feet and a travel of 35 feet.

The main shop is served by a 15-ton electric traveling crane, which spans the entire width of the shop, a distance of 53 feet, and travels the entire length of the shop. This crane, which was built by Niles-Bement-Pond Company, has a 3-ton auxiliary hoist for handling lighter work. Jib cranes are installed at all of the machine tools. These were erected by the company, and are equipped with common trolleys and hand-power hoists, manufactured by the Read Crane & Hoist Company. Since there is no electric plant installed in the shop, electric power for the traveling cranes is furnished by the Edison Electric Illuminating Company.

In the blacksmith and flanging department, shown in Fig. 2, besides the ordinary blacksmith tools there is installed an 800-pound hammer, furnished by the Niles-Bement-Pond Company. The shop is heated by the Sturtevant system of hot-air pipes, using exhaust steam. A complete equipment of pneumatic tools, riveters, forges, etc., is installed. A siding from the Philadelphia & Reading Railroad extends through the shop, giving ample shipping facilities.

FIG. 2.—BLACKSMITH AND FLANGING DEPARTMENT.

ENDURANCE OF FLUE MATERIAL IN LOCOMOTIVES.*

BY ALEXANDER KEARNEY.

Briefly considering the prominent features of the locomotive boiler, we find it was but a few years ago that the heavy freight locomotive carried but 140 pounds pressure. These boilers, doubtless many of you recall, had but the single-riveted foundation rings, and few of them were machined, while to-day, with boilers carrying 200 and 235 pounds pressure, the foundation rings are of necessity double riveted and machined throughout. All straight sheets, save the back flue sheet, have had their bracing reinforced; all circumferential seams have been substantially double riveted in place of the single course, and in the longitudinal seams we now find triple and quadruple riveted butt joints supplanting the plain lap. The thickness of the material has gradually increased from ½ inch to 1½ inches in some of the sections, and it is not unusual to find ⅝-inch material in the first-barrel course. For well recognized reasons the thickness of fire-box sheets has remained in the neighborhood of ⅜ inch throughout, except the flue sheet, which is about ½ inch for an average.

During this period of evolution the only prominent change in the flue has been its increased length, say from 13 to 20 feet. Its thickness has remained practically within the limits

* From a paper read before the Richmond Railroad Club.

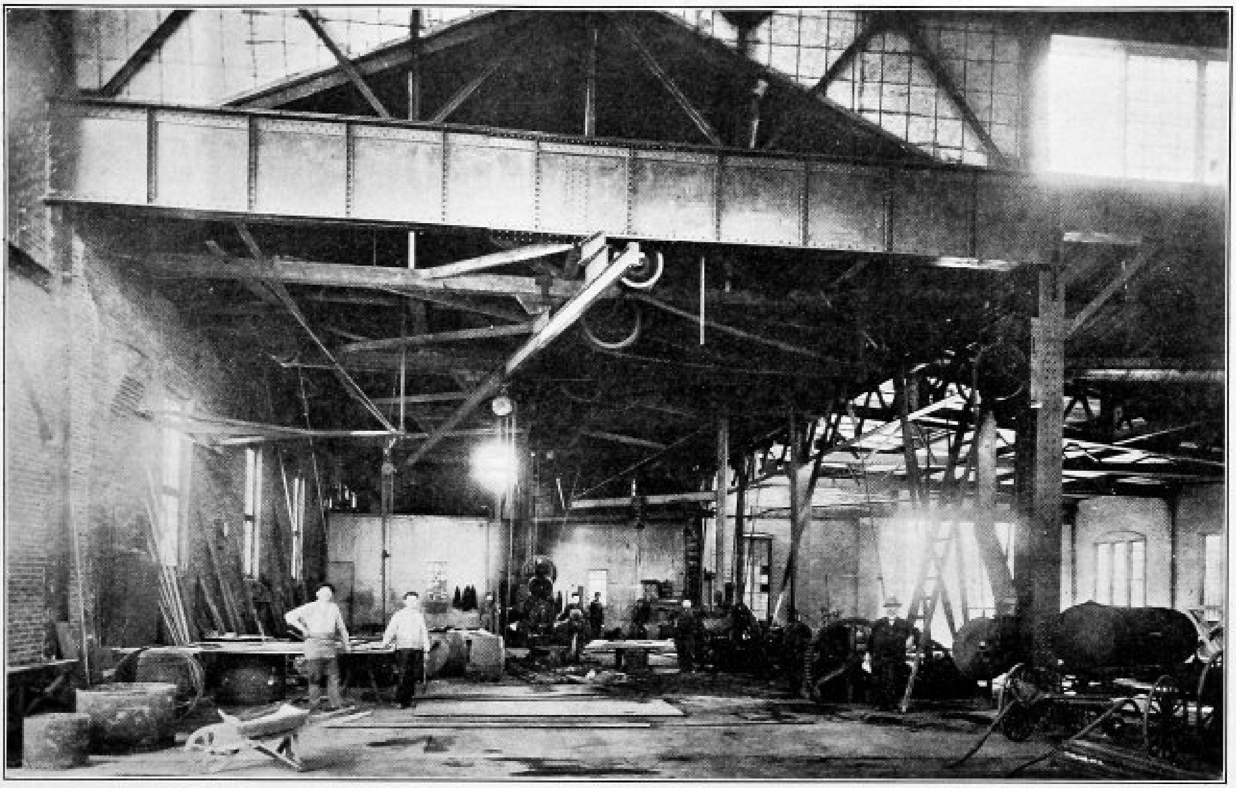


FIG. 3.—LAYING OUT, PUNCH, ROLL AND SHEAR DEPARTMENT.

of 12/100 of an inch and 135/1000 of an inch. The manner of setting in the back and front flue sheets has remained unchanged. The present method of fastening consists of rolling in the front sheet, and in addition to that operation, beading over at the fire-box sheet as it has been handled for years.

It would seem that the present type of locomotive boiler with its limitations has restricted innovations in this direction. We, of course, have in mind the watertube type, but the present development of the art does not possess sufficient merit to make extensive experimentation attractive. It is well known that many locomotive boilers of the watertube type have been constructed and used abroad, but the design has not commended itself in this country.

Accepting for the present these apparent limitations, we

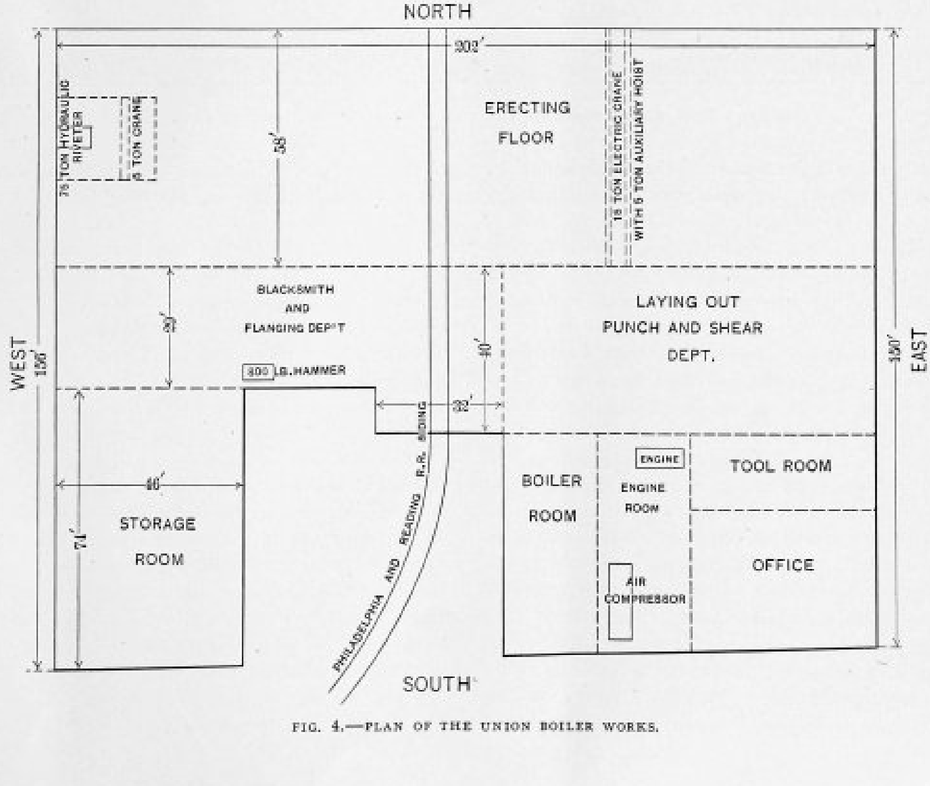


FIG. 4.—PLAN OF THE UNION BOILER WORKS.

venture to refer, in a general way, to the method of application before taking up the main theme of this paper, *i. e.,* the flue material, its composition, and the changes which determine its endurance and govern its life under service conditions. It is assumed that this phase of the question will prove interesting, if for no other reason than that it has received less general discussion.

Mr. M. E. Wells, in a very interesting paper, read before the Master Mechanics' Association in 1906, covered most completely the methods in use throughout the country, and touched quite generally upon the practice abroad. I feel that we have been impressed with the marked similarity in practice the world over, and yet what a diversity of opinion we find when considering vital details! And this is doubtless because the available devices can practically be narrowed down to the sectional expander, roller and the beading tool. It is not my intention to especially discuss the tools and their manipulation, although it is of the greatest importance, and so much depends not only upon the way they are handled but the time at which they are used. It might be said, however, that it would seem that the more general use of the expander is being favored. Retightening a flue in the sheet undoubtedly has the tendency to draw the bead with whatever tool is employed; and while such a result is not pronounced with a properly constructed expander, it is decidedly so with the roller. The destructive effect thus produced by reason of rapidly thinning the flue, especially under the roller, is serious, and very materially reduces its ultimate life. To ascertain, if possible, the effect of rolling as compared with the process of expanding in determining the life of the flue bead, a test was recently made, but the results obtained were by no means satisfactory. The mileage of the two engines was approximately the same, but the data could hardly be accepted as conclusive, as it was evident that the beading tool had not been used to the best advantage.

While any working of the bead produces crystallization we would infer that, as the expander is followed up with the beading tool, the flue sheet will be more or less guttered, but this can be reduced to a minimum by proper manipulation. On the other hand, when excessively rolled, the beads are abnormally drawn and become longer, and this stock added to the bead is distorted, which unduly finishes the fiber, materially hastening a gradual but certain destruction. This being so, it would appear that beads are sacrificed for flue sheets and vice versa, depending upon which tool is used and the manner in which it is handled. By careful manipulation the gutting of the flue sheet can be so controlled within proper limits as to make the general use of the expander profitable and desirable.

In this direction, an experiment was made by placing the ends of the flues flush with the fire-box side of the flue sheet, but this was done with an engine equipped with the so-called reinforcing sheets, which made it a simple proposition. In the first experiment the engine was given 159 flues with the beads left off, as described, and they were all put in the lower portion of the sheet, which, as is generally known, is the location where the flues have the shortest life. In among these 159 flues, fifteen were put in with beads, and they were located in the lower central portion of the group of 159 left without beads. While all of the flues required a certain amount of attention, the number of times the non-beaded flues were worked upon as compared with the fifteen with beads, was as one to two and three-tenths. Encouraged by this experiment, and being able to continue in service engines with so many of their flue beads burnt off, other engines have been fitted up, leaving the beads off of all the flues in the fire-box end, but our observations have been so limited we do not feel that we should, at this time, attempt to draw any definite conclusions.

FIG. 5.—ERECTING FLOOR OF THE UNION BOILER WORKS, LOOKING EAST.

This brings us to the consideration of the material, a phase of the question full of interest and apparent possibilities. In our studies we have confined ourselves to the fire-box end of the flue, having been especially attracted thereto by the fact that it seems to be the vital spot requiring attention in service. Our investigations have been planned with a view of securing data to determine, not only the group of metalloids, but the constituent parts most suitable for the service to which the end of the flue is subjected. For years the trend was markedly in the direction of charcoal iron, on account of its purity. Concurrently the manufacture of steel was being rapidly mastered, and it is thought by some (though the opinion is quite evenly divided) that steel offers greater possibilities for securing a more uniform product and one therefore less liable to corrosion. It is not disputed that in steel less segregation should be found, especially with respect to the carbon, and in proportion to this perfection of the material, should be reduced the tendency towards electrolysis, and hence, corrosion or breaking down of the material in the various forms wherein it is manifested. Some very interesting suggestions have been made with reference to the further perfection of steel in tubes by improving its ductility, which would possibly place it in a class of special steels. This has been carried along the line of annealing and hardening of the surface, in order to make it less susceptible to corrosion and the other destroying influences.

Here it might be mentioned that some of the rarer metals, such as vanadium and titanium, have been suggested as purifying agents, in that by their use a better product can be obtained. The material is supposed to be increased in strength and ductility by the presence of the smallest amounts of these deoxidizing agents, the theory being that the major portion of the cleansing agents possibly disappears in the process of purification. However, it is not our understanding that they should replace carbon, while the latter may be somewhat reduced during the elimination of oxides of iron and nitrogen, which process should increase toughness in the intra-crystalline structure and increase the interlocking of the crystals in the aggregate.

Our investigation of flue beads failing under mechanical punishment, due to loss of vitality, aggravated perhaps by chemical reaction, we regret, has been more limited than should be expected in view of the abundant opportunities offered, but the data we have been able to accumulate might be interesting. It is quite well known that all metals, when heated to the higher temperatures and then subjected to certain gases, will absorb them to a certain extent, holding them by mechanical occlusion, but the net product may be seriously impaired by a direct combination with the constituents in the metal proper, having formed new and very dangerous impurities.

A clearer understanding of our research cannot be had without going somewhat into detail. Upon analyzing portions of the metal removed from beads worn under the effect of service, we found, by accident, that by treating them with a diluted solution of hydrochloric acid, a very rapid evolution of gases accompanied by an unmistakable odor of hydrogen sulphide resulted. This suggested that either the flue material was highly impregnated with sulphur in the original manufacture or that sulphur found its way into the metal from the fire-box gases. To determine this point a number of badly deteriorated beads were examined, and in every case the sulphur evolved as hydrogen sulphide was decidedly higher than that allowed in specification material. It appears that the bead had undergone a gradual absorption of sulphur, and the amount of sulphur was greatest at the extreme end of the bead, decreasing as we receded, until the normal sulphur content was found. Constant working and rebeading of a flue produces incipient longitudinal cracks in the beads, which grow as the material is gradually weakened by crystallization. We might also infer that as the material is alternately opened and closed a certain amount of gases, probably sulphur dioxide, nitrogen, etc., are held mechancally. While these gases are confined, a sulphide of iron may be formed along with the unstable nitrides of iron. By further reaction and decomposition, sulphide of iron is probably evolved, thereby explaining the increased amount of sulphur found by the evolution method employed. The amount of sulphur at the extreme end of the bead after the deterioration had reached an advanced stage, ran as high as .1371 percent, decreasing to .041 percent at a point about on a line with the fireside of the flue sheet, which also approximates the sulphur found under the surface of the flue about 1¼ inches back from the fireside of the flue sheet. On the water-side of the same flue, and the same distance from the flue sheet, the sulphur was found to have decreased to .0253 percent, varying from that to .03241 percent, which was about normal. Assuming that the percentage of sulphur hastens the deterioration rather than otherwise under the higher temperatures, we might reasonably expect to find the bead under certain conditions entirely deprived of its original ductility. But this disintegration can hardly be attributed to the abnormal amount of sulphur alone, although its absorption seems to be in progress, and to play its part in disarranging and disrupting the metal structure.

The other gases that might be referred to with products of combustion and air passing through the fire-box are oxygen, hydrogen and nitrogen, the latter two being powerful in effect but most difficult of determination. These two impurities are present in iron and steel in varying quantities from a mere trace to, say, .02 to .03 percent, and there seems to be but little doubt that nitrogen in unstable combination is a very dangerous impurity. When iron is heated to a very high temperature in the presence of ammonia gas (a compound of nitrogen and hydrogen), an amount of nitrogen is absorbed, with the result that the physical properties of the material are entirely altered. One investigator cites a case coming within the range of our conditions, where a bar of carefully puddled iron, containing .004 percent nitrogen, failed with a decidedly crystalline fracture, and also mentioned another experiment where the nitrogen was .01 percent, and the fracture was even more crystalline, and the material more brittle. And this, as has been stated by eminent authorities, explains why steel made of the Bessemer process shows a somewhat lower ductility than corresponding grades of open-hearth steel.

Returning again to the service to which the flue is subjected, we find that gases running as high as 1,400 to 1,700 degrees are impinged upon the beads, and it is reasonable to expect that this condition is a favorable one for gas absorption. In a very interesting article read by Mr. Wickhorst before the American Society for Testing Materials, in 1906, on "Fire-Box Steel—Failures and Specifications," the statement is made that the temperature of the flue sheet probably at no time exceeds the temperature of the water in the boiler by more than 50 degrees F., provided the circulation is sufficient to keep the water always in contact with the steel, and the parts are free from scale and mud. But it was further stated that with ⅛-inch scale the metal attained a temperature of 200 degrees F. above the temperature of the water, and with 1½-inch scale about 400 degrees. This condition would seem to have very direct bearing and a material influence upon the flue bead.

Phosphorus is another impurity exerting a very serious influence upon the value of the material. Occurring as a phosphide of iron, it will vary from .008 percent in some of the open-hearth steels and best grades of charcoal iron to .015 percent found in some special grades offered. The influence of this impurity is seldom detected in the ordinary method of static test, but it is generally recognized that a softer material may be exceedingly high in ductility under static test, and very brittle under dynamic conditions.

That fluctuating amounts of silicon and carbon in phosphorous steel increase or decrease the tendency towards brittleness seems rather an open question, and, inconsistent as the statement may sound, some very high phosphorous steels have shown up well under service conditions. Silicon is usually assumed to aggravate the effect of phosphorus. We should say, in the light of our investigation, that the lower phosphorous steels, showing the finer structure, will have greater ductility, although it does not seem to be clearly established that materials containing higher phosphorus will not give equal, if not longer, service. Silicon is usually found in such small quantities that its influence has not been given definite value, but, if any were given, it would be that of increasing ductility.

The two constituents having the most influence on the value of flue material would seem to be manganese and carbon. Manganese is generally supposed to increase strength by toughening and counteracting the influence of sulphur, diminishing the fusibility of the metal, and decreasing the tendency towards lamination.

The idea prevails that a low percentage of carbon improves the resistance to higher temperatures; a very desirable characteristic. The condition of the combined carbon and the manner in which the flue ends are annealed temporarily improve the character of the material, thereby making the initial working incident to application less destructive. Still, it is a curious fact that many roads have already abandoned the practice of annealing, and without apparently affecting the life of the flue. That being the case, we might assume that the effect of annealing is so small that it is soon lost under the excessive temperatures to which the flue end is subjected. The presence of a small amount of slag, which is characteristic of iron, has been claimed as the reason why the material should give a higher resistance against corrosion, but as yet we are not ready to admit that there is any marked difference between the two materials in the resistance to corrosion when carefully manufactured. The corrosion of the flue by the action of the water in the boiler under steam-making conditions has given us little trouble, and no doubt for that reason we have not made as systematic study of that phase of the subject as may later seem advisable. Whether or not corrosion by galvanic action is present, where the flue and copper ferrules come in contact, cannot be definitely stated; but we have thought it is a point that might be a determining factor in the leakage of flues.

To attempt to fix upon proportions with maximum and minimum values for the different impurities would seem to be a difficult problem, but our observations indicate that for open-hearth steel the combined carbon should run approximately .080 percent, manganese from .20 to .30 percent, silicon below .04 percent, sulphur below .035 percent, and phosphorus below .04 percent. For charcoal iron the combined carbon should run approximately .080 percent, manganese from a trace to .08 percent, sulphur below .035 percent, phosphorus below .040 percent, and silicon below .050 percent.

Corrosion, if we accept the most plausible theory, is distinctively an electrolytic action, and is influenced by the relative potential of the constituent parts of the assembled materials. Any impurity which would tend to cause segregation would proportionately vary the relative positions of the positive and negative nodes—a condition which would doubtless give the least resistance to corrosion by galvanic action at the junction of the flue and copper ferrule in the water side.

Quite extensive experiments have been made attempting to use copper flues, and probably iron flues with copper-safe ends; brass flues also have been tried, but it appears that the most serious problem is to prevent the rapid destruction on the beads, on account of the abrasive action of the fire-box gases and cinder. This was very well proven in a recent experiment on the Norfolk & Western Railway by putting copper-safe ends in a consolidation freight engine equipped with the reinforcing sheet. The engine ran but a short time before the flues began to leak, which condition became continuous, the engine seldom going through a terminal without requiring attention. The beads were finally entirely burned off, and the ends of the flues were reduced to practically a knife-edge. The engine was finally withdrawn from service, the flues having made but 9,189 miles, which is about one-fourth of the mileage we should expect to get with iron or steel.

The softening of water for boiler purposes has claimed attention, and it is a proposition we have found necessary to study rather extensively. Experience would indicate that the amount of hard scale present is a true index to flue leakage. In our Ohio district we encountered extremely hard water, which resulted in overcrowding our shops with power on account of flue failures; but after the installation of water-softening plants at all of the important stations a decided reduction was obtained, which at once improved the general efficiency of the power. There is hardly a question but that the presence to an extent of hydrates and carbonates in treated waters decreases the tendency towards corrosion, leaving to be controlled the amount of total solids and excess of reagents so as to prevent boiler foaming. The use of soda ash in waters containing free acid, or any dissolved salts, such as magnesium chloride, decreases corrosion, thereby increasing the life of the flue material.

Concluding, it might be said that all of these factors alluded to have their influence on the ultimate life of the flue. They are the most important factors in the proper maintenance of the engine, save when the engine is on the road and undergoing preparation at terminals. It is well known that certain engines are brought in day after day requiring no attention to the flues whatever, while others in practically the same service seldom make a trip without failure, and this is a condition we can only hope to improve by constant education. Notwithstanding the assertions that cold air entering the fire-box has no serious effect upon the flues, experience, at least, teaches that it is quite possible to produce, or reverse, these very conditions by the manipulation of the engine and fire. And while this range of conditions is not far removed from average service, yet they are of themselves so severe that the possibilities in the further perfection in the materials, with whatever improvements can be accomplished in workmanship, may be entirely lost.

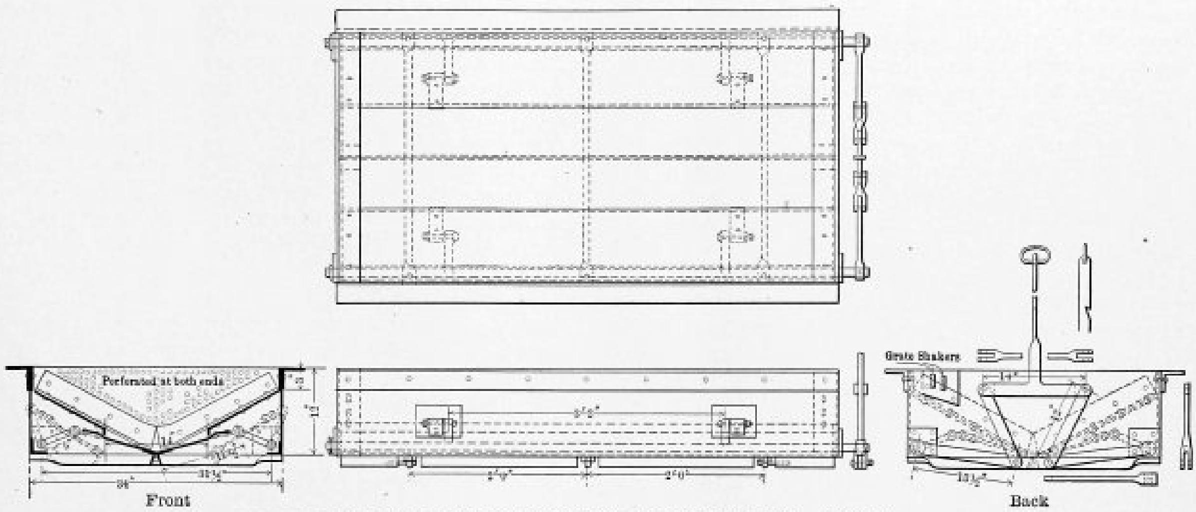
SUMMARY OF BOILER EXPLOSIONS, FROM 1879 TO 1907 INCLUSIVE.

YEAR.	Number of Explosions.	Persons Killed.	Persons Injured.	Persons Killed and Injured.
1879	132	208	213	421
1880	170	259	555	814
1881	159	251	313	564
1882	172	271	359	630
1883	184	263	412	675
1884	152	254	251	505
1885	155	220	278	498
1886	185	254	314	568
1887	198	264	388	652
1888	246	331	505	836
1889	180	304	433	737
1890	226	244	351	595
1891	257	263	371	634
1892	269	298	442	740
1893	316	327	385	712
1894	362	331	472	803
1895	355	374	519	893
1896	346	382	529	911
1897	369	398	528	926
1898	383	324	577	901
1899	383	298	456	754
1900	373	268	520	788
1901	423	312	646	958
1902	391	304	529	833
1903	383	293	522	815
1904	391	220	394	614
1905	450	383	585	968
1906	431	235	467	702
1907	471	300	420	720
Totals	8,512	8,433	12,734	21,167

A NEW DROP-BOTTOM ASHPAN.

BY R. W. CLARK, FOREMAN BOILER MAKER, N. C. & ST. L. RAILWAY.

Ever since the enactment of the new law requiring that some form of self-dumping or self-cleaning ashpan shall be applied to locomotives on or before Jan. 1, 1910, much attention has been given by boiler makers to the development of a successful device of this kind. The illustration shows a new drop-bottom pan which is being used with success on one of the engines of the N. C. & St. L. Railway, carrying a shallow ashpan. The pan can be easily operated with one hand in the cab of the engine, by means of the lever through the deck just under the fire door. To clean the pan, simply pull the lever up as far as the crank will permit. To close the pan, let go of the lever and the pan will go back to its original position, and will remain closed until the lever is again pulled up. To clean the fire, there is a notch in the lever to hook in the deck by pulling the lever slightly towards the operator; and to close the pan after the fire has been cleaned, it is simply necessary to kick the lever out from the deck, and the pan will close itself and remain in this position.



DETAILS OF THE NEW DROP-BOTTOM ASHPAN USED ON THE N. C. & ST. L. RAILWAY.

This pan can be operated while the engine is in motion without any interference whatever with the engine, as the slides do not come lower than the bottom of the pan. It is absolutely tight and does not drop the fire. There is no damper, and, therefore, it can be kept tight at all times. It can be applied to the original pan with very little cost and is applied to the engine without any changes whatever. Therefore, it is a very economical type to install.

The pan has been in operation for thirty days and has given perfect satisfaction, adding greatly to the steaming of the engine, as the fire can be well shaken out and at all times kept clean, due to the simple operation of the pan.

A thorough test for warping has shown that it is not affected in this respect at all. It will exterminate all clinkers that may accumulate in the bottom of the ashpan, and, in the opinion of those who have had anything to do with its installation and operation, it has proved a very simple and durable type and meets all requirements of the new law.

English Locomotive Boilers are usually fed by injectors, which are generally of the automatic restarting type. In some cases exhaust steam injectors are used. On two lines pumps are provided, with economical results. Gage glasses are usually fitted in duplicate, and are protected. They are, of course, provided with taps to enable a broken glass to be replaced. On the London & North-Western, internal ball taps are provided, where the flow of steam and water is automatically stopped on a glass breaking.

Very little attention is paid to the design of smoke-boxes, probably on account of the very slight knowledge obtainable of the action of the blast. In most designs there is a quantity of water space in the box, in which the blast has to form a vacuum. Eddy currents are probably set up, causing efficiency to be lost. The most efficient smoke-box would seem to be one embracing the tube area only, and changing by gradual curves into the plane of the exhaust. The blast pipe is, as a rule, high, the exhaust nozzle standing between the center line of the boiler and the top row of tubes. Low blast pipes are now finding favor, and should be more efficient. To promote freedom in the formation of the vacuum, smoke-boxes should be as free as possible from pipes.

THE SMALL ECONOMICS OF A POWER PLANT.

BY A. S. ATKINSON.

The power plant of a modern up-to-date electric railway system represents the most important point where economy can be practiced, and where losses can almost imperceptibly mount up to ruinous figures. Much depends upon both the general equipment of the plant and the method of its operation. We have, within the past few years, increased the efficiency of the power plant 20 to 30 percent, and eliminated losses from it which may easily be placed at another 20 percent.

The evolution of the power plant is far from being completed to-day. At present the steam turbine for electric railway service has placed the reciprocating engine and internal combustion engine on the defensive, and every effort is being made to increase the efficiency of these two prime movers. They have responded much slower to the challenge than they should, but their improvements are steady. The relative value of these three forms of prime movers in the railway power plant of the future is a question that vitally concerns the designing engineer, and there is reason to suppose that their ultimate adoption in any one plant is a matter that local conditions will largely influence. The tendency is apparently to unify one or two of the prime movers for a single plant. Both the reciprocating engine and low-pressure steam turbine can be utilized profitably in the same plant, and where these two types are properly co-ordinated the results are gratifying.

But aside from the question of securing higher efficiency from the prime mover, there are important considerations of economy derived from proper operation of every little detail of the equipment. Sometimes an apparently unimportant loss grows to a great one in the course of a year. Thus the very first question of the thermal value of coal is one that cannot be ignored. In the recent official tests made with different coals it was found that the variations in their thermal value was so great as to make all the difference in the world between profit and loss.

In the modern plant, chemical tests of coal are to-day made before large purchases are made. Payment is thus made for fuel according to its thermal value. The most satisfactory results can be obtained by securing a small quantity of coal from different dealers and burning it in a bomb calorimeter to ascertain the thermal value and the amount of ash and sulphur. The loss in the latter is sometimes so great that a cheap grade coal proves, in the end, enormously expensive. It is apparently only a question of time when coal for plant fuel will be sold almost entirely by this method and not according to its bulk or weight, irrespective of its grade and quality.

In burning any kind of coal, however, the nature of the grates, boiler room and stacks must determine largely the general efficiency of the plant. The loss in the stack ranges from 20 to 30 percent, and it is one of the most vulnerable points for attack. A little designing and improvement may reduce this loss one-half. In most cases this loss is due to an inadequate stack, or to the admission of too much air to the combustion chamber. The cooling of the combustion chamber by such admission of an excess of air generally causes the losses.

An examination of flue gases will show the amount of loss, but then it is not always so easy to ascertain the cause. One may be due to poor feeding of coal to the furnace so that "holes" are made in the fire. These holes in the fire admit the excess of cold air and cause losses. Better stoking will prevent this. The automatic stoker, properly adjusted, will prevent such "holes," for the feeding and distribution are made uniform and even throughout. The improvement in the grate, furnace bars and size of stack may also tend to eliminate the losses from imperfect combustion. It has been repeatedly demonstrated in some of the best plants of the day that this average loss in the stack of 22 to 30 percent can be reduced to 12 and 13 percent, and in a few instances it has been brought down to 10 percent. By scientific methods in the boiler and firing room the saving thus proves of the greatest value, whether the latest type of engine and machinery are used or not.

The loss in boiler leakage and radiation is another vital point to the central station engineer. Good results cannot be shown where this loss is allowed to develop without check. In the old engineering practice very little attention was usually paid to the loss through radiation, and only when leaks became serious was attention drawn to this form of steady drain. In a great many engine rooms the loss from these two sources will amount to 8 or 10 percent without attracting special attention. In a majority of cases this is due to improper boiler setting. The designing engineer is primarily responsible for the boiler setting, but the operating engineer should know when this is inefficient. Bad boiler setting usually means rapid destruction of the brickwork through improper distribution of the heat, and an increase of draft by infiltration. In some plants the amount of air admitted to the furnace has proved a serious problem, simply through infiltration. The engineers have attributed the excessive draft to the grate, poor stoking and size of smokestack, but alterations in all of these did not remedy the trouble. The brick boiler setting was then examined, and after it was properly reset the trouble disappeared. With the increase of draft the infiltration of air increases, and up to a certain point this becomes so great that the loss through imperfect combustion is enormous. Sometimes where the infiltration cannot be stopped at once by new boiler setting, it is possible to secure some relief by placing an iron plate air-tight case outside the brickwork. This case should enclose a carbonate of magnesia lining to make it fireproof. If properly placed, this plate may stop the excessive admission of air and secure temporary, if not permanent, relief.

The question of boiler leakage is probably a more serious one than the air infiltration due to bad boiler setting. As a rule the leakage is less in the tubular form of boiler than in the water-tube type, as the former have a smaller number of joints in the water space, but where high-pressure steam is used the tubular form is more apt to develop structural weakness, and it is more difficult to build and set up. The repair of leaks is difficult enough in any case, and the very difficulty of it induces many engineers to let the matter go until conditions of safety actually demand it. The life of a boiler depends more upon the care given to it than upon its construction, and every leak at the joints increases the strain upon its most vulnerable part. When this strain is permitted to go on unnoticed it becomes in time so great that a general breakdown is probable. The first sign of a leak is the time to make repairs. The loss, after all, is of only secondary consideration to the danger threatened. By keeping the boiler in the best working condition all the time, its life of service may be indefinitely extended. Economy of practice demands that boiler leaks should be located and repaired as soon as they show. Sometimes this is not easily ascertained, except by a study of the steam gage, which should indicate any serious loss.

The proper heating of the feed-water before it enters the boiler is recognized to-day as one of the fundamental necessities of all good steam practice. The problem of doing this without waste of energy or power differs in various plants according to the design and the nature of the auxiliaries. Where all the auxiliaries are steam-driven this is possible without great trouble. In this way their exhaust can be utilized for heating the feed-water. If the auxiliaries simply paid for the cost of operating them and keeping them in repair, they would still prove profitable investments if their exhaust was utilized in the feed-water heater. This fact is not always emphasized in plants where the value of keeping the feed-water at a proper temperature is not fully recognized. With economizers the feed-water can be increased in temperature to 200 or 250 degrees F., and with all the auxiliaries operating at 80 percent thermal efficiency, the gain therefrom is enormous. This increase of temperature is obtained from the waste gases and there is consequently no expense for fuel in operating the economizers. While it may not always be advisable to install economizers, it is pretty generally accepted as a good rule that they pay where the load factor exceeds 25 percent. Whether it will pay to make this investment where the load factor is lower than this is somewhat debatable.

When we come to consider the waste in pipe radiation of a steam plant it is important to consider the distance at which the steam is delivered. Pipe radiation loss is less to-day than formerly, for nearly every large plant to-day has proper pipe protection, whether laid underground or above. This protection saves from 10 to 20 percent of the loss in uncovered pipes. The life of the pipe protection has also been extended by improved methods, so that the investment can be considered good for fifteen to twenty years. By that time the saving has more than justified the investment. With a two-layer pipe covering, 1 1/5 inches thick, the radiation losses are practically reduced to a minimum. An engineer who refuses to consider this point is hardly competent to manage a modern up-to-date plant. It is one of the small, but in the end important, losses which determines the final profits of the plant.

It will be seen from the foregoing that the loss in the engine and boiler room depends more upon small items than upon any large one, and upon the degree to which these are remedied will the final success of the plant depend for its efficiency. In addition to those mentioned, there is the loss in engine friction and the loss in leakage and high-pressure drips. If the latter are returned to the boiler, this will not amount to much. In reference to engine friction it has been found that mechanical efficiency of 93.65 percent at full load can be obtained in good practice, leaving only 6.35 percent for engine friction. This relatively small loss should be the maximum toward which a good engineer should aim. But very few plants show such low loss in engine friction. The reasons for greater loss may be looked for in the method of lubricating and poor adjustment of bearings. By the flushing system of lubrication, the oil is distributed to the principal parts from an elevated reservoir, and after passing through the bearings is returned by gravity to oil filters below. From there it can be pumped back to the reservoir tank. The engine is thus thoroughly lubricated in all parts and the loss in oil is very small. It is possible to pass 200 gallons through such a system with a loss of only 0.5 percent. There can be no question about the efficiency of such an oiling system, and in the end it pays better than any hand system. Engine friction is reduced to a minimum and the saving in oil more than pays for the installation in a year.

The importance of avoiding friction of any part of the engine by keeping the bearings in good condition is apparent to anyone, but frequently it is neglected. To a good engineer any creaking or cranking of any part of an engine is a danger sign, and he immediately seeks the cause. If in all cases this defect is immediately remedied, the engine's life will be saved for a much longer period, and the loss from friction will be eliminated. We are steadily increasing the burdens placed on our engines, and with this increase comes a greater strain, unless every part runs smoothly. The modern engine is more expensive than the old types, and it is built stronger and with greater resistance power, but at the same time it demands proper attention. Nothing lessens the life and efficiency of an engine so much as to permit it to run under a strain. Eliminate the cause of the strain and the engine will graciously respond.

The design and construction of the electrical generators are of paramount importance in any railway system, but so well have engineers and manufacturers perfected this branch of the station work that the loss of efficiency is not nearly so problematical as in the boiler room. The best generators in use to-day among our railways shows an efficiency of 98 percent and more. This remarkable efficiency seems to indicate that further improvement in this direction does not call for extended work and experiment. With generators of such standard make the engineer cannot show great loss in their operation.

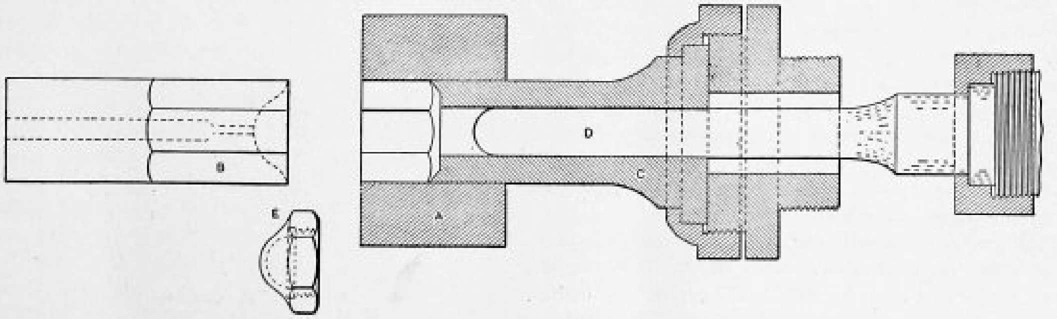
There is one point, however, that deserves more than special notice. This is the question of adapting dimensions to suit varying sizes and speeds. A poorly designed generator for a given work may represent considerable loss. Constructing and designing engineers seek to make the generators of appropriate size to suit all the problems arising in a given station. It is this feature of the work that calls for no little study.

The question of designing proper generators and apparatus to take care of great overloads economically for short periods is one that vitally concerns every central station. The peak loads of a railway or electric lighting station vary so much in the course of the 24 hours that it requires designing of special kind to provide apparatus which will handle the work economically. The plant which has a generator capable of handling an overload of 100 percent economically is in a fair way to make profits for its owners. The failure to do this properly means loss and waste.

From a study of the conditions pertaining to an ordinary power plant for electrical railway driving, it may be said that scientific operation in the engine room should improve the efficiency over the old types about 25 percent, and at the same time increase the output. This is accomplished without the installation of turbines or internal combustion engines for auxiliary work. The ordinary reciprocating engine is taken as the type of prime mover, but with such auxiliary equipments as feedwater heaters, economizers and mechanical stokers. The introduction of the low-pressure steam turbine to operate on the exhaust of the reciprocating engine, or an internal combustion plant in regions where producer gas is very cheap, may give even better results, but they need to be treated by themselves, and a plant designed for them requires radical changes from the foundation up. The present article is concerned chiefly in increasing the efficiency and output by adopting more scientific methods in a plant supplied with the ordinary reciprocating engines and their modern essential auxiliaries.

Making Nuts for Flexible Staybolts.

A contributor to *Machinery* gives the following interesting method of making nuts for flexible staybolts. In the shop where this method is employed a drop forging press is not available. This device was therefore designed to be used on a 1½-inch Ajax nut machine. The nut blank is placed in a holder *A*, and the die *B* holds it in place. The punch *C* then moves forward and crowns the nut, and finally punch *D* is fed forward and makes the recess into the blank for the thread at the same time that the projection is thrown up on the end of the nut. The finished nut is shown at *E*. This process of making nuts has proved a complete success, it being possible to make 1,000 in 10 hours.



DEVICE FOR MAKING NUTS FOR FLEXIBLE STAYBOLTS.

DESIGN FOR AN ASH PAN.

BY WILLIAM E. O'CONNOR.

Ash pans to suit the present-day locomotive are very complicated, to say the least, owing to the peculiar design of the boiler. Especially is this true of the Wooten type of boiler, known better to railroad men as the Hubbard type of engine. "Cut-outs" must be made for wheels, spring hangers, braces to boilers, etc. Ash pans are required to carry the refuse from the fuel to terminals, and also to regulate the proper amount of draft for combustion. In the dry season they must be kept in good repair, to prevent the dropping of fire while crossing culverts, bridges, etc.

We are now getting out pans from the designs shown in the illustration and from similar designs in groups of 8 and 10 from standard templates. The only angle iron used in the construction of this pan is at the base of the mud ring of the boiler, the holes are all laid out and punched, and the sheets flanged and the several parts assembled by the apprentice boys. The riveting is done in the following manner: Button-head rivets are entered from the outside; a dollybar is placed against the point of the rivet; the action of the air hammer on the head upsets the rivet on the inside, which makes a nice appearance at minimum cost.

To lay out this pan we will deal with the principal parts only. First draw up an end elevation of the hoppers, the depth of which is shown to be 24¾ inches, plus 2½ inches, which extends into the casting marked "A2,595." Next draw up a side elevation on a sheet large enough to make the sides, the depth of same being taken from the end elevation. The slope of the front and back hoppers is obtained in the usual way. One inch from the boundary line draw a parallel line for the rivet holes. Lay off all the rivet holes and mark them on the different sections, as shown. When this side is trimmed and punched, the other side is marked from it. Lay out the different sections and mark them. Holes at *F* are omitted in the sides and marked from the section after it is formed. The upper part of the pan needs no explanation. The half-

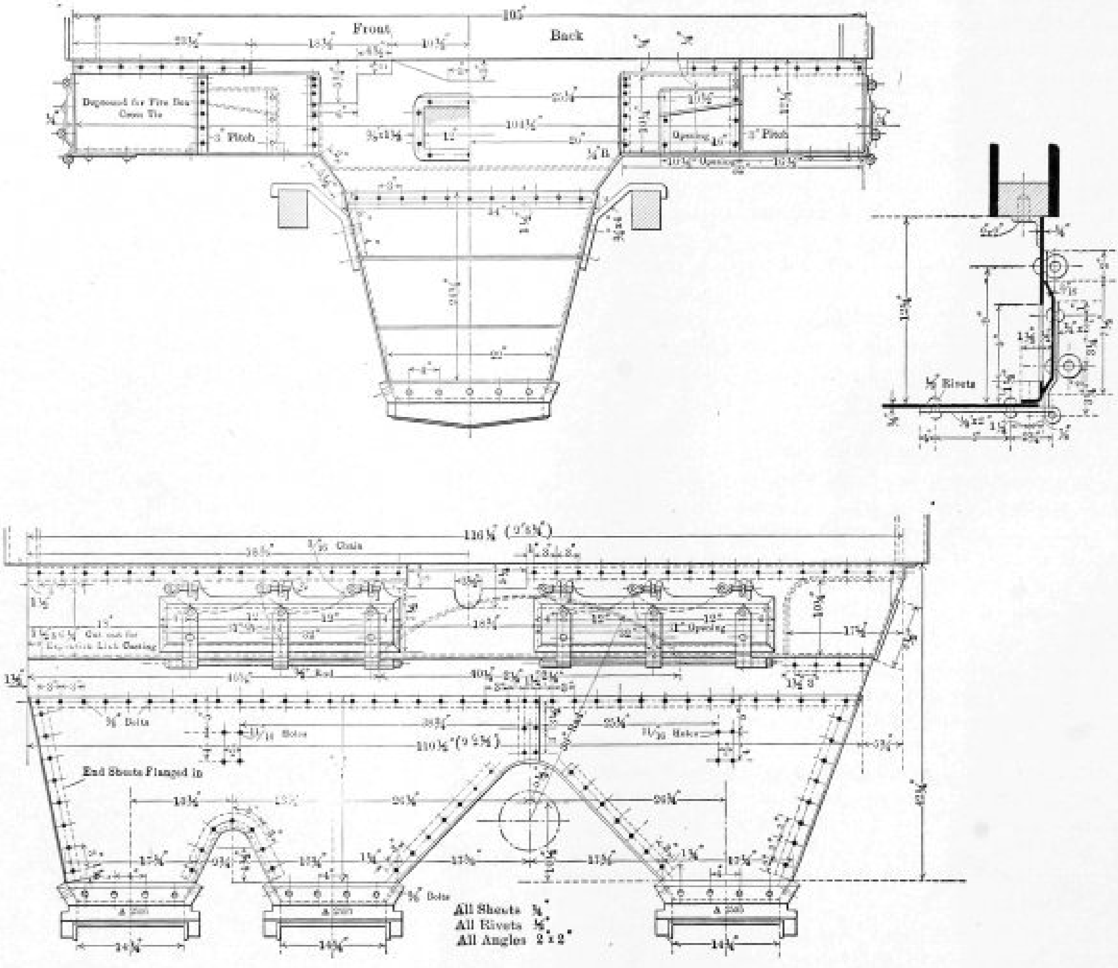


FIG. 1.—DETAILS OF ASH PAN.

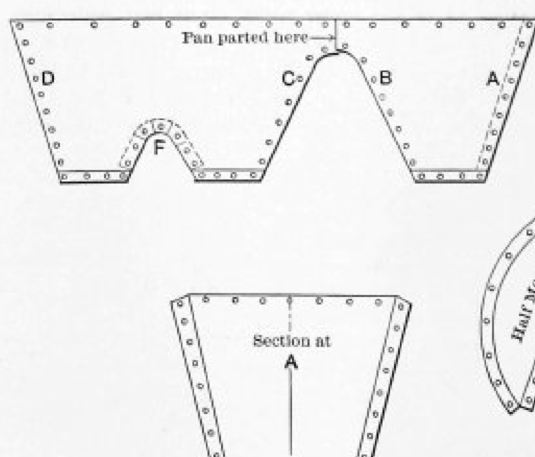


FIG. 2.—LAYOUT OF ASH PAN.

moon pieces are all laid out in straight sheets. Two cast-iron slides cover the bottom. Gravity keeps them closed, as will be seen from the slope of the casting in the end view.

THE BRICK ARCH VS. BOILER EFFICIENCY.*

BY GEORGE WAGSTAFF.

A free steaming locomotive is becoming every day more valuable to the railroad and we realize more and more the necessity of making our locomotive boilers more efficient, as we cannot hope to obtain a much greater capacity, as the locomotive boiler has now reached its limit in size, on account of the physical conditions of the railroad, consequently we are face to face with the proposition of getting the maximum amount of work from the locomotive boiler; and the object of my paper this afternoon is, to present to you what I believe is one of the practical and feasible methods at hand for so doing. Therefore, I will discuss, for a few minutes, the relation of the brick arch to the efficiency of the present-day locomotive boiler.

A review of the history of the bituminous coal burning locomotive brings forth most prominently the importance that the brick arch played in the earliest attempts to burn bituminous coal, and when the problem of changing from wood to coal necessitated the successful burning of bituminous coal, the motive power officials, at that time, used the brick arch as one of the efficient appliances to bring about that result and a careful review of the opinions of motive power men of the period shows the high regard in which the brick arch was held, and clearly demonstrates its recognized value in locomotive operation at that time.

As the burning of bituminous coal became an easier problem with the increased knowledge, gained from experience, the brick arch commenced to receive less attention, and, as the efficiency of the locomotive boiler was not a relatively important factor, the importance of the arch commenced to decline and it commenced to be attacked in the house of its friends, as it became easier to obtain larger boiler capacity by the simple means of increasing the size of the boiler without necessitating particular attention to its efficiency. This condition continued until recent years, when we have come face to face with the proposition that the larger boiler capacity cannot be obtained by this simple means and we must work in other directions to obtain increased efficiency, for which motive power officials are being called upon to-day as strongly as in former years.

The value of the brick arch in this latter period of the history of the modern locomotive boiler as a means of further increasing its capacity, has already commenced to be recognized by many of the best railway systems in the country. At the present time, if we may judge from the discussions of this subject by leading mechanical experts and organizations interested, we must conclude that the brick arch has again come into its own and must be reckoned with as an important aid in operating efficiently the modern locomotive.

In studying this subject from all its various standpoints, weighing the advantages and disadvantages and the opinions pro and con, of those who have used brick arches, I cannot help but express myself strongly in my belief, that, in view of the recent great improvement in boiler care and maintenance, in addition to the successful treatment of water, and the successful improvements in hot water boiler-washing plant, etc., that the disadvantages claimed for the brick arch have almost been practically overcome.

From the earliest history of the arch there does not seem to have been any question about its advantages and its value in locomotive operation, and therefore, with the wiping out of the disadvantages, the non-use of the brick arch means the practical throwing away of a large amount of valuable power. The arch is recognized as the most efficient device for reducing the quantity of sparks thrown from the stack, and, on this account, it becomes directly valuable as a fuel saver. It increases the length of the flame weight, and the finer fuel, when lifted from the grate, is baffled by the arch, and is consumed, instead of passing directly to the tubes and out of the stack in the form of sparks. It causes more equal distribution of the draft over the grate, and thus improves the furnace action. Its function in the firebox being that of a mixer and baffle, it brings about a more complete mingling of the gases, and thereby aids combustion resulting in the higher temperature, and the production of a smaller proportion of carbonic oxide. These claims have been fully sustained by the measurements made in the locomotive tests conducted by the Pennsylvania Railroad at St. Louis in 1904.

The two consolidation locomotives there tested were almost identical in grate area and heating surface, but one of them was equipped with the brick arch and the other was not. The draft riggings in the smoke boxes were not alike; one being arranged to clear the box of cinders, while the other allowed them to remain in the front end. However, the effect of the brick arch on sparks and cinders is shown in the total amount drawn through the tubes, which is given as an average (for the four tests at 150 revolutions) of 380 pounds for the boiler with the brick arch and 505 pounds for the one without.

The temperature of the firebox as an average of the above four tests was 2,202 degrees F. for the brick arch, and 1,982 degrees F. for the tests without it. The maximum temperature was 2,312 degrees F. with the brick arch, and 2,112 degrees F. without it. The firebox with lowest temperature had the highest amount of CO, due to imperfect combustion. The maximum percentage of loss of heat in coal fired due to imperfect combustion of CO was only 2.09 for the brick arch and 16.33 percent for the firebox without it.

The above advantages of better combustion and consequent fuel economy are only a part of the advantages to be obtained from the use of the brick arch, and in my mind, in view of the problem of the present-day operation, they are the smallest. We know that the first requirements made of the motive power department, by the operating department, are to furnish efficient power in order to move the traffic, next, to move it expeditiously and, last, as economically as possible.

We know that the economy frequently is, and must be, lost sight of when large movements of traffic confront our railroads and it is in this situation that I believe the brick arch assumes its largest value to the railroad.

We have frequently seen instances where a poor steaming engine or engines have seriously impeded the movement of traffic, resulting in congested terminals, delayed passenger trains and a large amount of overtime for the employees in all classes of service. These are losses that can hardly be measured in dollars and cents, as the ability of a road to pay dividends is directly dependent upon its ability to handle its traffic with the minimum amount of delay.

It may seem to some that I place an exaggerated importance upon the brick arch in its relation to the modern locomotive boiler, but I cannot see, in view of the present demands made upon the motive power department, how any devices that increase the efficiency of the locomotive boiler from 5 to 10 percent, can be allowed to pass with any less consideration.

* From a paper presented before the Central Railway Club.

Fusible plugs should be made of a bronze casing filled with Banca tin at least ½ inch diameter at the smaller end.

FLANGING BOILER PLATES.—VII.

BY JAMES CROMBIE.

Use of the Sectional Flanger.

The four-column hydraulic press, while capable of handling the bulk of flange work that is required in a boiler shop, still leaves a large field that it cannot touch, hence the need of another machine that will take care of this larger class of work, such, for instance, as the ends for large marine boilers, which are too large to go inside the four columns of the press. This large work is nearly all flanged on what is known as the sectional or universal flange press, one of which is shown in Fig. 72.

These machines are made in sizes up to 5 feet gap and are usually fitted with two vertical rams, one holding down the plate, and the other, which is parallel with the clamping ram, carrying the flanging die, forcing down the projecting plate and forming the flange. When this ram is flanging down the plate it will spring away from the plate to a certain extent and to take up this side pressure in some machines a cast-iron flange is used as shown in Fig. 73. This is bolted to the base of the machine and acts as a slide and keeps the flanging ram rigid while descending. From the back of the machine and through the frame there is a small horizontal ram which, passing through an opening provided in the cast-iron flange, can be used to press down any humps and true up the flange. This ram is shown clearly in Fig. 73. These sectional machines are also provided with a bottom ram, which is used for clamping purposes, when flanging with complete formers, as shown in Fig. 72.

A number of years ago good flange work used to be done under the steam hammer. The hammer was equipped with suitable formers (Fig. 74) and large heads were flanged up to 15 feet 6 inches diameter by 1 1/16-inch plate with a flange 8 or 9 inches from the face of the plate or for a double riveted seam of 1 5/16-inch rivets in 1⅜-inch holes.

The plates were heated in a large fire built to suit the radius of the plates. The draft was supplied from the bottom, a box made of old boiler plate having its top level with the floor, forming the tuyere. The top of the box had a large number of holes, which were stopped up with rivets and fire-clay according to the size of fire required; the sides were then built up with several rows of firebrick and filled with coke. The plate was then heated on this fire, which gave a good heat about 15 inches broad by 6 to 9 feet long; the heated portion was then put under the steam hammer and broken down a little all along. The plate shown on the face of the hammer (Fig. 75) was then thrown off and the flange hammered down into place, the plate being fed under the hammer gradually by small hand cranes at either side. The plate was passed several times under the hammer, the last pass striking a quick light blow and leaving the flange in a nicely finished condition.

The body of the plate would sometimes buckle a little, and in that case the flanged sections of the head were heated all over in the plate furnace and hauled onto a large straightening block and flattened. To do this a large weight working on an overhead wheel was pulled up quickly and then dropped by a squad of men, two men guiding the blows of the weight by a couple of small chains. This soon flattened the worst humps or buckles in the plate.

It was afterwards finished with the flatter and sledge hammer. A plate was attached to the frame of the steam hammer and extended outwards and carried the center pin. This pin could be moved to center the largest sized heads. A hole had to be dug in the earthen floor to allow the opposite end of the plate to travel around.

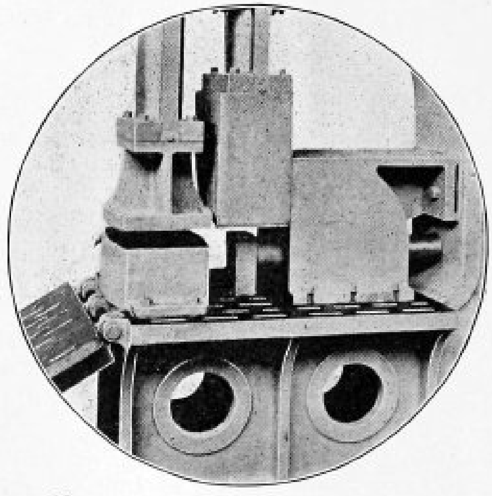


FIG. 73.—METHOD OF SUPPORTING THE WORKING RAM.

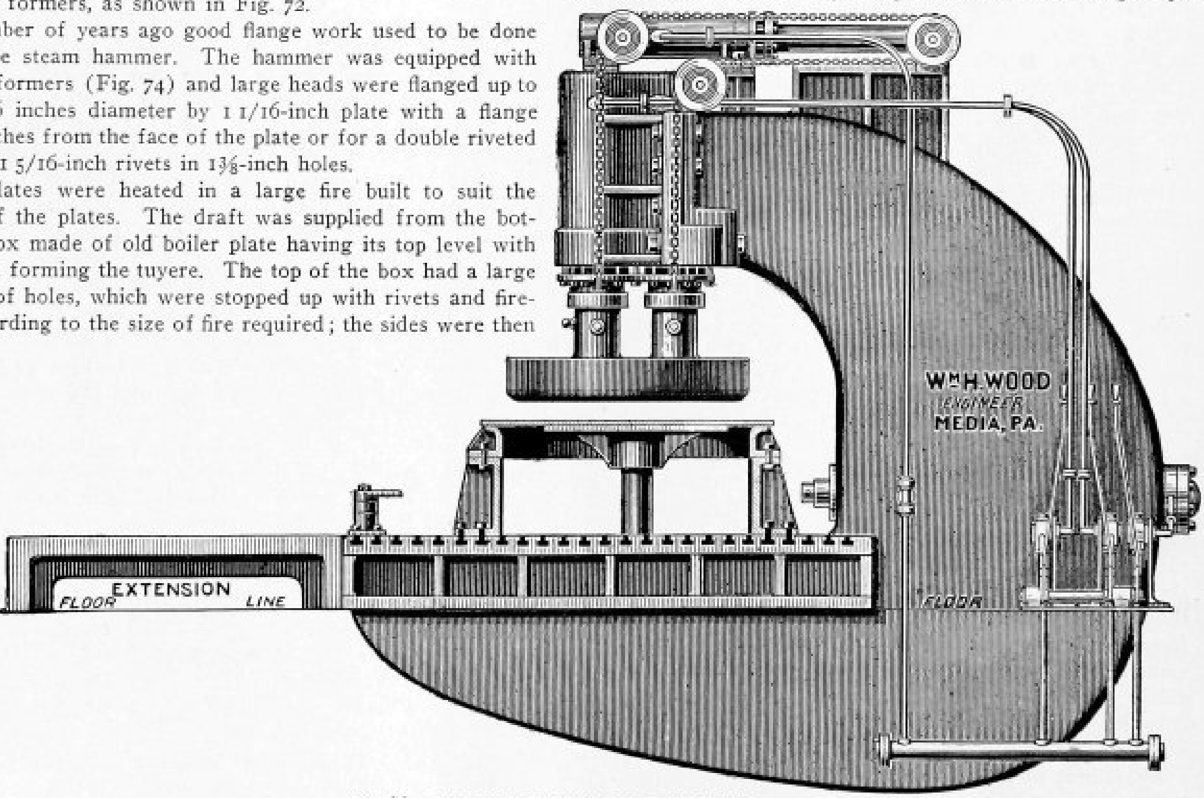


FIG. 72.—SECTIONAL OR UNIVERSAL FLANGE PRESS.

The whole process was somewhat similar to hand flanging, the steam hammer with its heavier blow taking the place of the sledge hammer and the costly hand flanging. This process, as already mentioned, has now given place to the progressive system of flanging by means of the sectional flange press, with which, as in the four-column press, the flange is formed by a squeeze instead of a blow, without injury to the plates.

The dies are made in sections from 12 to 24 inches in length. These same sections can be used for a great variety of work and are easy to handle. They do not take up much space for storage. Costly patterns have to be made to cast complete formers for the four-column press, and when the complete dies are made they are heavy to handle and require a large amount of valuable space in which to store them, a fact which counts largely in favor of the sectional-flange press.

When flanging large circular heads in the sectional press it is the better plan to set the plate from the center, a center pin being bolted on to the table or to an extension if the job is very large. If it is not possible to get a hole through the plate to fit on this pin, a centering block may be used. This can be bolted on to the under side of the plate to be flanged, the bolts going through the tube holes or other suitable holes. Fig. 76 shows the outer tube plate for a large marine boiler with the centering block in place.

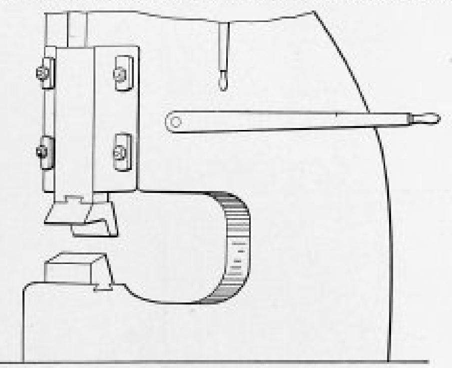


FIG. 74.—FLANGE FORMERS APPLIED TO A STEAM HAMMER.

One end of the plate is heated in the furnace or a suitable fire and flanged in one heat, the outer ram clamping the plate and the inner ram turning down the flange. The center end is flanged in this way. The flue holes can be flanged either in sections or with complete formers at one squeeze as in the four-column press. Complete formers for this circular hole may be made up of a series of steel rings which can be reduced or added to, instead of having only one pair of formers for each size of hole.

Fig. 77 shows the end plates for a marine boiler 15 feet 6 inches diameter. Both seams in the center plate are punched, also the pilot holes for the tube-hole cutter. The cross seams in the upper and lower plates are marked after the flanged end is fitted into the boiler shell to be drilled, these seams being punched or drilled when the end is taken out to be cleaned. The inner tube plate and back of center firebox for this boiler are shown in Fig. 78; the wing firebox back and tube sheet are also shown in the position they will occupy in the boiler (see Fig. 79). The tube sheets are 7/8 inch thick and the back of firebox 9/16 inch thick. When one considers the cost of flanging these plates by hand, or the cost of complete formers to flange them in one squeeze in the four-column press, and the limited number of plates required, one begins to realize the importance of the sectional flange in the boiler shop.

The inner tube sheets and back of the firebox are flanged under the sectional flanger by suitable sections of dies, 18 to 24 inches being turned down at a time, the corners being left until the last. The corners are then flanged, the formers shown in Fig. 80 being used. The former is a piece that will catch both sides and squeeze them into place; the bottom of the former is rounded so that it will gather in the metal as it passes downward. In laying out these plates for flanging, the straight parts of the flange will require to be left the full width of the desired flange, or take, for instance, the 9/16-inch plate, the finished size, plus 3/8 inch for the turn, plus 2 7/8 inches flange will be correct, as there is not any gather along the straight part. The circular part around the bottom should be about 1/4 inch narrower than the required flange, as it will gather and form the required breadth when finished. The greatest gather is at the top corner and these will have to be sheared accordingly, or about 1 1/4 inches less than the required flange (Fig. 81 shows two corners, one correctly sheared and the other showing the gather of the plate when not sheared correctly). In this case the flange is for 7/8-inch diameter rivets.

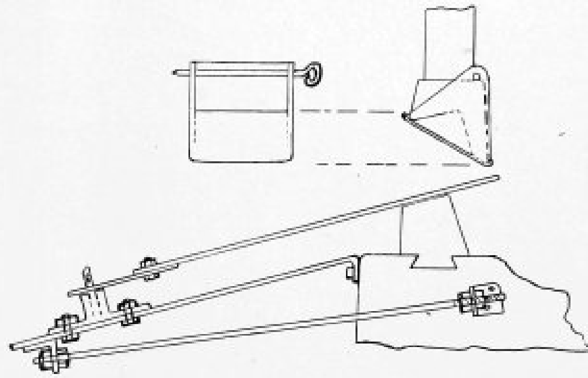


FIG. 75.

To flange these corners the former *A*, Fig. 80, is fixed to the vertical flanging ram and a square block with the corners suitably rounded is fixed to the table and adjusted for the thickness of the plate. The corner of the plate is heated in the fire and placed upon the block, the vertical ram quickly clamps the plate down upon the shell and the ram with the former *A* then descends and gathers the plate and forms the flange; the metal bracket at the back keeps the former *A* rigid while it descends. The flange can be squeezed true by the use of the horizontal ram.

The uses to which the sectional machine may be put are almost numberless. Not only are flat plates of irregular shape flanged, but with suitable formers a great variety of curved shapes may be formed. Sections of Adamson type flues may be flanged and plates of large diameter dished. For dishing plates a die, which is shaped like a "saucer" or concave block, is placed on the table of the machine. The former has a convex-shaped face and is fixed to the vertical ram. Such a plate is set up cold. It is placed in the dies and the pressure applied; the plate is then worked gradually into the required spherical shape as it is fed around under the formers. A plate dog, or heaving dog with a ring, is fixed to the plate to

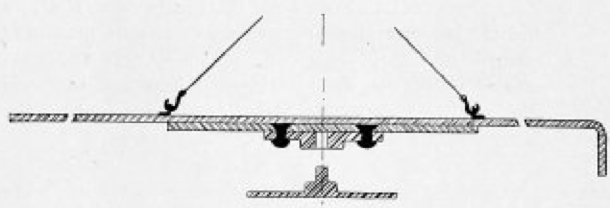


FIG. 76.—CENTERING BLOCK FASTENED TO TUBE PLATE OF A MARINE BOILER.

suspend it from the crane. Butt straps and the ends of heavy shell plates can be set up to required radius with a former shaped on the face like a "fuller" or swedge. Sections of large cones can also be set up with the same former, or the straight flanging head may be used with two blocks laid on the table some distance apart with a lower block between the two. This space can be packed up with several pieces of plate to suit any radius. As the plate is formed cold, it will not show any sharp kinks, but can be gradually worked along into shape.

These are a few of the every-day operations that occur in the contract shop and serve to illustrate the use of one of the boiler maker's best helps, the sectional flange press.

The formers, shown in Fig. 69, Chapter VI., for flanging domes in one heat, can also be used on the sectional flange press, if the press has enough clearance between the platen and the vertical ram to allow the dies being used. The plate with the male formers can be suspended on a frame made of a channel or flat bar bent to shape. This frame will revolve freely, carrying each die under the ram to be squeezed in turn and so form the flange. The frame also allows a seesaw motion to raise the male dies clear of the female die so that they can swing round.

Manhole saddles are required in every boiler shop and are easily made under either the four-column press or the sectional press. They are flanged in one heat by complete formers. Dies for flanging these rings are suitably bolted to the vertical rams, with the female die bolted to the platen. The plate has a small hole punched out of the center and is heated and placed on the dies and squeezed down, one stroke turning down the flange and also forming the plate to the radius of the boiler. The saddles are then machined on the face of the flange to take the manhole plate and gasket.

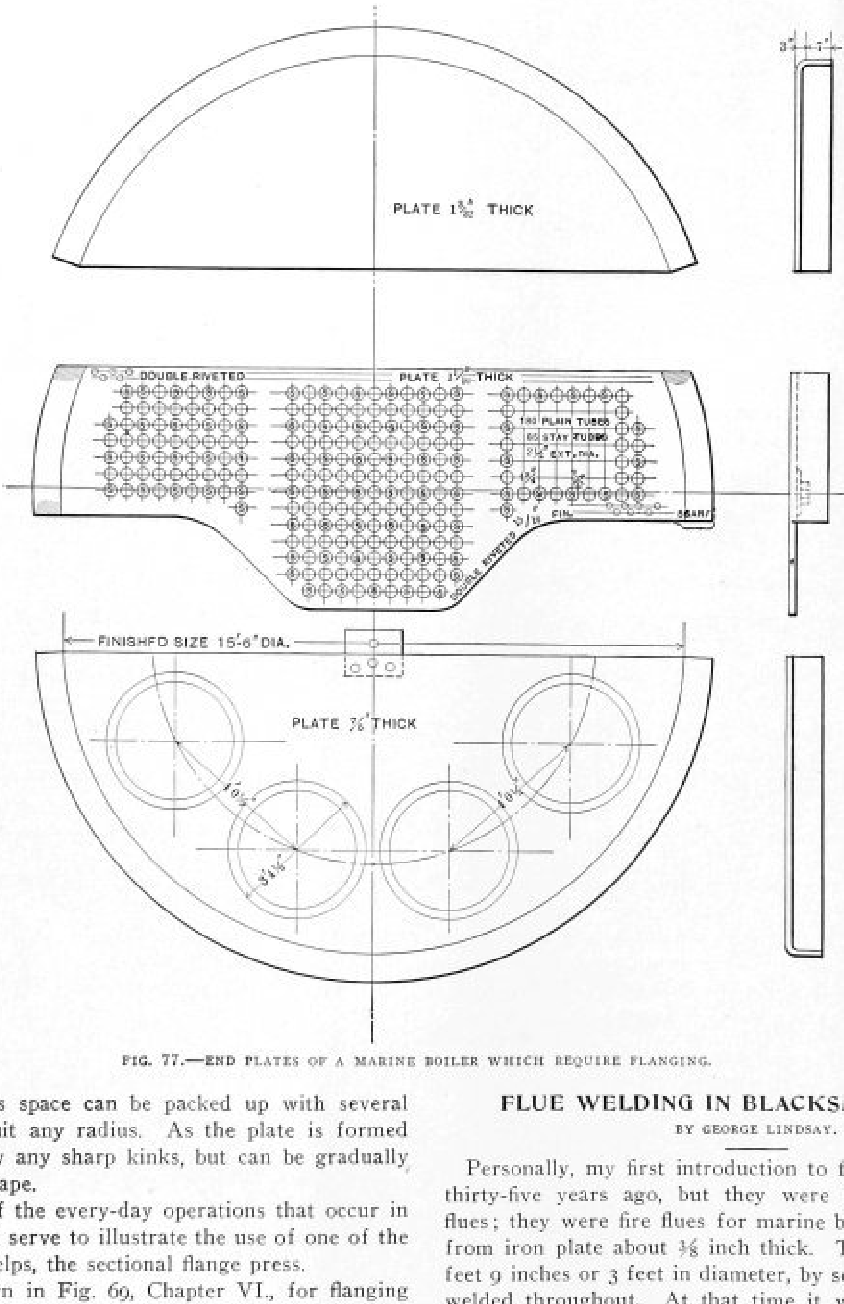


FIG. 77.—END PLATES OF A MARINE BOILER WHICH REQUIRE FLANGING.

FLUE WELDING IN BLACKSMITH SHOPS.*

BY GEORGE LINDSAY.

Personally, my first introduction to flue welding was some thirty-five years ago, but they were not locomotive boiler flues; they were fire flues for marine boilers, and were made from iron plate about 3/8 inch thick. The flues were about 2 feet 9 inches or 3 feet in diameter, by some 10 to 12 feet long, welded throughout. At that time it was not uncommon to make steam domes and weld the crown into them. I had some three years of this sort of work. I hardly knew whether I was a blacksmith or a boiler maker. However, to get closer to the subject in hand—"Locomotive Boiler Flues—Welding," there are some fundamental points essential to success. To begin at the beginning—cleaning. There are various methods, but the rattler, either wet or dry, I like best; the inside is clean as well as the outside. When the scale is removed on the outside only, as in some of the methods, many, if not all, have a coating of sulphurous deposit inside that materially reduces the chances of good welds, no matter how good the

* From a paper read before the International Railroad Master Blacksmiths' Association.

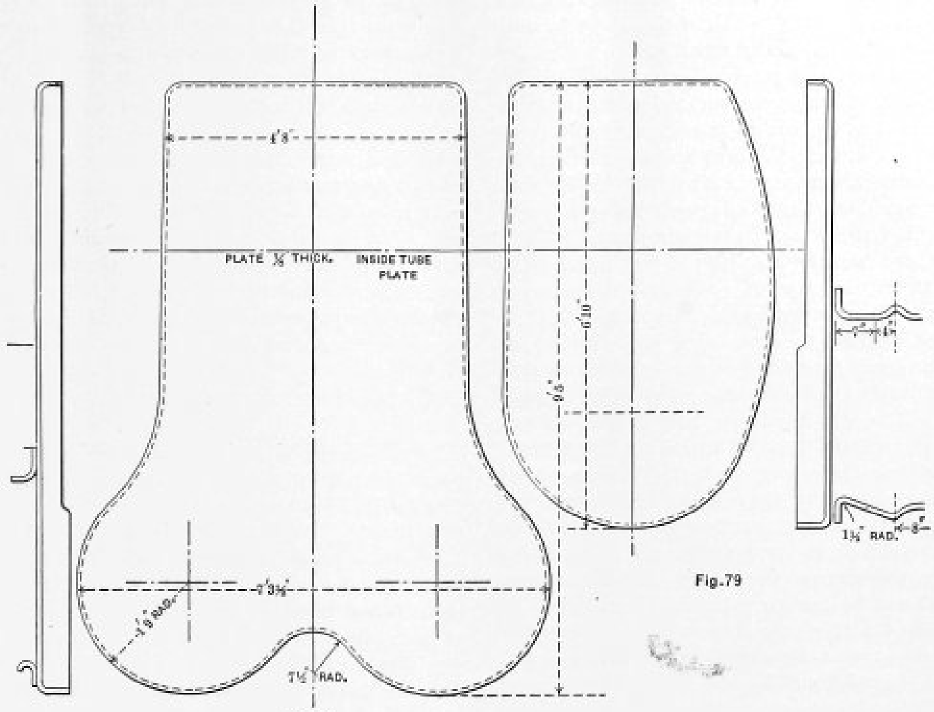


Fig.78

FIGS. 78 AND 79.—COMBUSTION CHAMBER PLATES WHICH REQUIRE FLANGING.

heats are, but with clean flues it is practical to do good work on them.

The next thing is the furnace. Flue welding now is much simplified by the various designs of oil furnaces, reducing the tediousness of the work. I believe no one will dispute the assertion that oil is the fuel. Some may not have the results that others have with oil. The first furnace I ever built was successful, and the second was not. I could not find the cause for quite a while, but finally all went well.

I have here a blue print from Mr. Northend, for which a good deal is claimed. Perhaps he will enlighten us on its merits. A great many manufactured furnaces are on the market, which seem to be good from the number in use. I have had no experience with gas; perhaps we will hear from some one who has. The very best fire-brick is none too good, and even that can be, and is, melted down by the intense heat, and

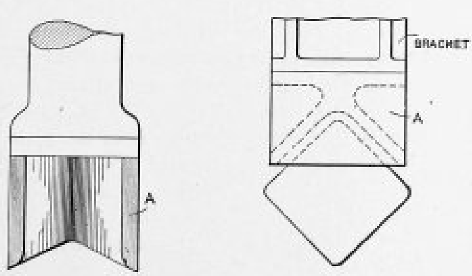


FIG. 80.—FORMERS FOR FLANGING SQUARE CORNERS.

it is very important for the operator to give close attention to this point. What benefit is it to rush welding? Perhaps so as not to have to begin next day to finish a set, by crowding the furnace for an hour or two, and have to spend more time in rebuilding it. Yet this is often the case.

In regard to the preparatory operations, there is not so much difference among us. True, we do not all have the *same* facilities, but cutting and scarfing does not cost one cent; each is very reasonable as to cost. Some say they do not scarf the flue at all. I don't care whether they do or not, if a machine roller or hammer reduces the tube to uniform size. If they do not, and have the tubes ⅛ inch smaller inside, a few figures will tell you that forty of them might as well be plugged as far as the area of draft is concerned, and will remain that way during all of their life. It might be said we swage the end, and that reduces the area as much. However, we are discussing flue welding, not draft. Let the boiler maker settle this. Good service seems to be had by nearly all, and the cost has been brought down to a very low figure. We don't hear anything about the butt welds now. I think they are gone for good on flues. With the prevailing facilities to work with, oil furnaces, air hammers and roller machines, plenty of room and air, the welding of flues is very nearly down to the limit. The prices do not vary much in different places. We do not do piece work, but feel we do the work for about the same as

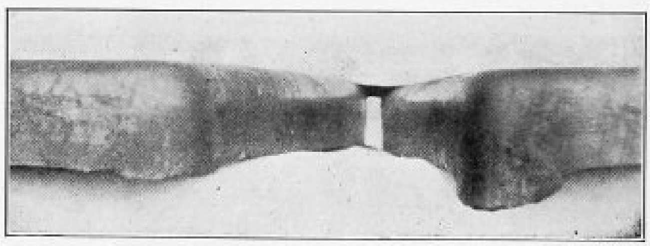


FIG. 81.—CORNER OF LEFT-HAND PLATE WAS CORRECTLY SHEARED FOR FLANGING. CORNER OF RIGHT-HAND PLATE WAS INCORRECTLY SHEARED FOR FLANGING.

those that do. I have prices paid on several roads which I will give if asked by anyone personally, as some don't seem to think publication would be fair to them.

DISCUSSION.

I do not think that one man is swedging and welding 350 to 400 flues in ten hours. If he said he did it with a welder and a helper it would be different. If he has two holes in the furnace, I cannot see where he is going to get much benefit by having three holes in the furnace. I weld by heating the end of the stack and the short part I weld in the furnace, and while it is getting hot the end of the short flue is put in the stack, which is hot and ready to receive the safe end by the time the other is welded. It only takes about forty seconds to heat the flue. We can heat as quickly as we can handle them with two holes, and I do not see why three holes are necessary. The safe end we put on the mandrel. The heat on the flue shrinks on the cold part. Put it in the furnace and get a light welding heat on it, and tap it on the arrangement that you have behind the furnace to make it solid, and put it under the hammer. We can weld 350 a day and have done it, but every man does not do it. We may get one fellow that will do it. Some think that if they do 250 they are doing well. I have got 350 done, but not for some time. When a man mentions that he can do 350 to 400 a day I would like to have him a little more explicit. He will have to have some help to handle them.

There are some who will fit them all together; heat a number of them and jam the safe ends on them, but they don't count the time it takes in cutting them and fitting them. We have to fit and weld them at the same time and swedge them. We put them right through and are done with them, and a man does not have more than one flue on his mind at the same time. He can give his full attention to the one flue. I believe better work can be done in that way than by heating a number of them. I see no need in having three or four in the fire at a time. We weld 2¼-inch flues. They get about 50 cents more a hundred for welding 2¼-inch than they do for the 2-inch. For the 3-inch they get 45 cents more than they do for the 2½-inch, which makes them about $2.50 for a hundred.

A Handy Clamp for Handling Flanged Plates.

I would like to call the attention of the readers of THE BOILER MAKER to a very handy tool for the boiler shop. This tool was designed for the purpose of lifting throat sheets from the fire to the block for flanging, and I think it is the handiest tool of its kind for that purpose; for it can be put on in an instant, and can be removed just as quickly when

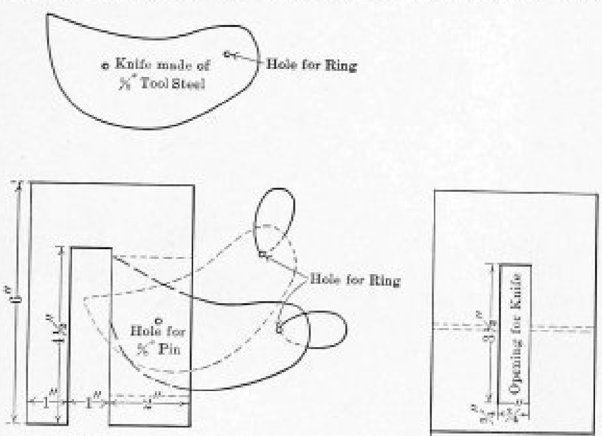


Fig. 1 Fig. 2

DETAILS OF KNIFE CLAMP.

the sheet is on the block. After the sheet is in position, there will be no chains or hooks in the way of the men striking at any part of the throat sheet. It is simple and can be made in any boiler shop. All that is required is a block of iron 4 inches by 4 inches by 6 inches and a block of steel as shown in the sketch. Take a block of iron 4 inches square and 6 inches long and cut a one-inch slot, as shown in Fig. 1, allowing for a 11/16 hole, as shown, for a ⅝-inch pin. Then turn the block over and cut a slot for the blade, as shown in Fig. 2. Make the blade so that when at rest, as shown by the heavy lines, the opening in Fig. 1 will be free to receive the plate; and when raised, as shown by the dotted lines, it will jam the plate so as to make slipping impossible. Finally put a ring on the end of the blade for a hook.

With two of these blocks around the shop you can lift flanged plates just as easily as you can lift flat plates with hooks. This device can also be used for various other things, such as carrying plates along on edge, pulling plates out of racks, or turning plates on the floor. The sketch here shown was made for throat sheets ranging from ⅝ to ¾ inch in thickness. For lighter plates the tool should be made to suit the work. It is hoped that this device will be of some benefit to those who have been lifting sheets out by hand or using screw clamps and chains or various other devices. W. C. R.

LOCAL WELDING IN RAILWAY SHOP WORK.

In the course of an interesting series of articles on European locomotive work in *The Engineering Magazine,* Mr. Charles R. King comments on the use of autogenous welding as follows:

The new processes for welding have been of the greatest utility for the work of railway shops, for they permit of the metal being fused *in situ* without having to dismount the parts to be repaired. In the work of new constructions these welding processes are largely employed. At the La Chapelle (Paris) shops of the Nord Railway the oxyhydric process is in use for welding all thin plates not subject to special working strains. Boiler flues are pieced together and frame plates are welded or soldered, after being fractured in service. For joining the clothing plates of boilers or cylinders—which require to be hermetic when no non-conductor is used for lagging the boiler—it is especially serviceable. A length of 1 meter of 1-millimeter thick plate is welded in ten minutes, consuming 20 liters of oxygen and 100 liters of hydrogen, and costing, together, 14 centimes—barely 3 cents; 1 meter of 2-millimeter plate is soldered in fifteen minutes, consuming 60 liters oxygen and 280 liters hydrogen. The proportion of hydrogen is much above the theoretical value in order to avoid oxidation.

The process is also employed in the construction and repair of steel and iron pipes, of ash-pans, locomotive foot-plates, and for all kinds of repairs where the flaws are superficial and compromise neither strength nor safety.

The outsider, in watching the process, sees the operator wearing dark spectacles, holding the burner against a 1¼-inch frame plate. The flame first blisters superficially; the iron then gradually becomes a blotchy red, losing color directly the flame is moved away, then reddening through the whole depth of the metal, and finally becomes white and attains the point of fusion, when the soft iron rod to fill the cavity is introduced and fuses with the neighboring metal of the plate being welded. With boiler flues the two coned and hollowed ends of the tubes are lightly butted together while resting on a X-trestle, and the operator touches the joint with the flame, forming a series of little fused points, turning the tube slightly with each touch of the flame. Each operator welds 120 flues daily, or an average of five minutes per tube, the cost in gas for each ten tubes being 100 liters oxygen and 650 liters hydrogen, costing, together, 81 centimes, or 16 cents. The saving as compared with the old system of brazing amounts to 40 centimes (8 sous, or 8 cents) per tube, or enough to pay for the gas required to weld five tubes.

An assistant removes the welded tubes and passes one extremity of the flue through a hole in a block, leaning on the other extremity, turning the tube slightly at each pressure. The tube, according to the foreman, never breaks at the joint, but gives way at any other part if the tube is tested to destruction.

Summing up the price of shop work in connection with this form of welding, each tube costs 32 centimes, or 6½ cents, for labor; that is, cleaning and cutting down old tubes, sawing off and chamfering the new ends for the fire-box extremities, welding, straightening; tests in the block and at the hydraulic press and trials at the store reception. The gas costs 8.1 centimes per tube, consequently each tube thus welded costs, altogether, 40.1 centimes, or 8 sous or cents.

The saving by this process for welding ribbed tubes of the Serve pattern is even greater; that is, 13 sous or cents per tube. The ends of the tubes are hollowed and coned as usual, the lip on the hollowed end furnishing the metal for the fusion of the joint. Each tube weld necessitates 60 liters oxygen and 243 liters hydrogen, together worth 37 centimes, or 7½ cents. Each installation turns out sixty welded tubes per day, or an average of ten minutes for each ribbed tube, for which 4 sous or cents per tube is allowed. The entire cost per tube amounts to 25 sous or cents—1 shilling—including cleaning, selecting and cutting down of tubes, removal of ribs at the extremities, sawing off the new end, chamfering the joints and, at the same time, removing the ribs near to the weld, welding, straightening and testing.

The two kinds of gases are delivered in steel cylinders of 47 liters capacity and at a pressure of 150 kilogrammes per square centimeter. Reduced to atmospheric pressure, each cylinder therefore contains about 7 cubic meters of gas, for which 16 sous or cents are paid to the "Société L'Oxhydrique Française" per cubic meter of hydrogen and 58 sous per cubic meter of oxygen. For thin metal up to 3 millimeters thickness this process is quite as economical as the oxyacetylenic process of welding, but beyond that thickness the latter is the more economical. By reason of its less intense whiteness the glare of the oxhydric flame is said to fatigue the eyes of the operatives less.

PRESSURE ON A STEAM BOILER.

BY W. H. BOOTH.

Some years ago it was desirable to raise the pressure of a certain steam boiler, but it was not thought sufficiently strong for the high pressure owing to insufficient strength about the mouthpiece of the manhole, which was of full size. Therefore, it was decided to rivet a stiffening ring of steel inside the boiler around the manhole opening, the rivets of the mouthpiece being, of course, cut out and replaced by new rivets through the three thicknesses.

Obviously a stiffening ring cannot be put on whole, because it cannot pass through a manhole. Such rings are, therefore, made in halves. It is obvious that two such half rings will strengthen a boiler shell quite as much as if they were one solid ring, provided the division line lies across and not lengthwise of the boiler.

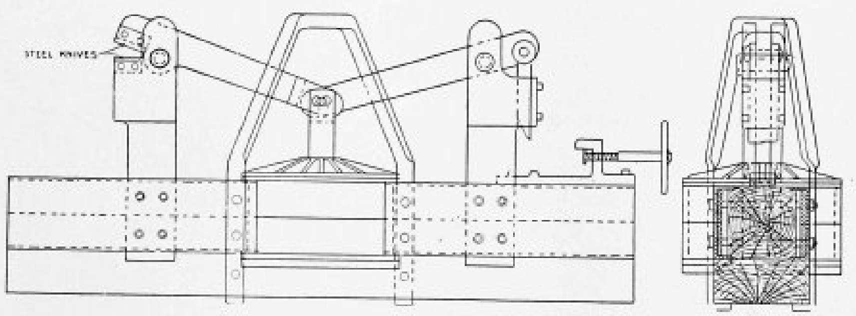
The shell of a boiler when cut away for a manhole hole is stressed along the longtitudinal center line at which the stress that should be borne by the cut-away portion is necessarily concentrated. The boiler tends to open out into two half drums by tearing along the longitudinal and not along the circumferential line. In the case in question the two halves of the strengthening ring butted together at the top of the boiler, the ring being riveted on after being turned 90 degrees.

This was worse than useless, for the plate had been pierced for additional rivets and rendered positively weaker. This is simply an example of how easy it is for good intentions to go astray. The owners followed good advice and employed a boiler maker to put on the ring when they felt free to raise the pressure.

There is always a wide margin for safety allowed in steam boilers, or assuredly this boiler would have exploded. The work was well done as regards quality, but it was clear that the boiler maker was no engineer and that he had not the simplest notion of stresses.

A very mathematically minded engineer, when told that a certain boiler flue of large diameter was showing signs of distress, applied to an inspector to calculate the diameter of the oscillating circle and see what was amiss and take steps accordingly. "Good heavens, man! what is the use of that? The thing has calculated itself and will collapse perhaps before the calculation is finished," was the reply of the inspector.

Fortunately the error was discovered before any harm was done in the first case, but in the second case an accident might have happened from too much learning. Is there not a tendency for a too mathematical mind to be obscure regarding matters of common sense?—*Power*.



SIDE AND END VIEWS OF SHEARING MACHINE.

A USEFUL SHEARING MACHINE.

BY IRA A. MOORE.

One end of this machine is used for shearing the heads off the rivets in draw-bar pockets for the purpose of removing the pocket, and the other end is a shear suitable for working over old bolts. It is capable of shearing up to 1⅜ inches round iron and will shear the heads off two draw-bar pocket rivets with one stroke of the piston, when a pressure of 90 pounds per square inch is used in the cylinder, which is 24 inches in diameter and 12-inch stroke and is fitted with a packing leather for upward pressure and one for downward pressure. The power is compressed air.

The lower end of the blade for shearing rivet heads is made with one side slightly longer than the other for the purpose of distributing the work required to cut the rivets through more of the piston travel than would be the case with a straight cutting edge on the blade. The air-distributing valve, which is not shown on the drawing, is made from a main valve bushing and slide valve from a 9½-inch Westinghouse air pump. The ends of the bushing are closed by means of plates held on by rods extending from one to the other. Into the center of one of these plates the bonnet from an old 1-inch globe valve is screwed, through which the stem passes that connects the slide valve to a suitable lever for operating it. All port holes in the bushing not needed are plugged up. To the bottom of the bushing referred to a brass piece is fastened, into which is tapped two ½-inch pipes, one of which leads to each end of the cylinder. On the side of the brass piece next to the bushing grooves are cut which connect the admission ports in the valve seat with the pipes leading to the cylinder. A slot is cut through the brass, corresponding to the exhaust port in the valve seat, which allows the exhaust to pass to the atmosphere. As these valves are made line and line for air pump use, about ⅛ inch outside lap was added to the valve, which enables the operator to stop and hold the piston at any point of the stroke. The distributing valve is fastened to the side of the cylinder by means of a clamp which passes around the bushing. This machine conveniently located will save considerable handling of material.—*Railway and Locomotive Engineering.*

UNNECESSARY LOSSES IN FIRING FUEL OIL.*

BY C. R. WEYMOUTH.

Practically all oil-fired boiler plants in stationary practice are subject to hand control throughout. It is customary to maintain a uniform oil pressure at the oil pump and in the oil-pressure main, and to throttle the supply of oil by hand at all of the individual burners. It is also customary to operate with full boiler steam pressure on the main supplying steam to all the burners, and to regulate by hand the supply of steam for atomizing purposes, at each of the individual burners. Boiler dampers also are all subject to hand control on the individual boilers.

In a central station having, say, twenty 500-horsepower boilers, there would be about sixty burners. For economy of labor, there would probably be not more than two or three firemen to the shift, in a plant of this size. On a commercial railway or lighting load subject to the usual fluctuations, such a plant would probably be operated with the rear boiler dampers clamped in fixed positions, wide open, or nearly so. The supply of steam to burners would receive little attention, but the supply of oil to the burners would be regulated for variations in load by throttling to the extent necessary for maintaining the desired steam pressure. In such a plant there would be a more or less uneven rate of firing at the various boilers, and an excess of air for combustion at all loads, particularly at the lighter ones corresponding to a nearly uniform rate of flow of air through the furnace. The operators are likely to become careless, not noticing the drop in steam pressure with a sudden increase in load until this has become considerable, necessitating a severe momentary rate of firing in a number of boilers to bring the steam pressure back to the normal. This severe duty increases the expense for repairs to the boiler settings, rate of burning out of tubes, etc.

In certain plants where engineers are enlightened as to the principles of combustion, the attempt is frequently made to operate on a reduced air supply, with the result, if the dampers are set for mean or nominal load, that the chimneys smoke excessively on overloads before the limited number of firemen can reach all the dampers to open them.

As the lamentable result of these conditions, the average boiler-plant efficiency with crude oil, even with the best types of boilers, averages much nearer 70 than 80 percent, which is possible in large plants under proper methods of control.

Probably it will always be impossible to instill into the mind of an ordinary fireman such knowledge of the principles of combustion and the losses due to excess air supply as to obtain economical results in large stations where it is necessary to depend on hand firing. Improved conditions can be secured by the employment of a boiler room engineer whose duty it is to scrutinize all fires from time to time and to coach the firemen in their duties; but the only ideal method seems to be an automatic system of control, such as will be here described, where the various adjustments, having once been made for economical conditions, are automatically repeated for the various conditions of load, maintaining a high average economy from month to month. With well-designed oil furnaces and careful adjustment under uniform load conditions, carefully conducted tests have shown that it is possible to obtain high percentages of CO_2, indicating as low as 10 percent excess air over the requirements for perfect combustion, with no unconsumed elements in the flue gases.

Numerous data relating to coal fuel are available, showing the importance of reduced air supply as tending to high furnace efficiency; also the relation of excess air supply to any observed percentage of CO_2 and other factors of gas analysis. As few data for oil fuel are available, the following will be presented.

All Pacific Coast crude oils contain a certain amount of moisture, sulphur, nitrogen and oxygen; the main constituents being carbon and hydrogen. The characteristic difference in oils of different gravities lies in the relative quantities of carbon and hydrogen contained, there being more carbon and less hydrogen in the heavier oils, less carbon and more hydrogen in the lighter. In the better grades of oils treated at the wells before shipment, in which moisture has been largely eliminated, it can be roughly assumed that 3 percent of the oil is made up of sulphur, nitrogen, oxygen and water. This relationship is not universal, certain Southern California oils containing a large percentage of sulphur.

The predominating oil used on the Pacific Coast, known as Bakersfield oil, averages about 16 degrees Baume; which is equivalent to 336 pounds of oil per 42-gallon barrel. The ultimate analysis of this oil is about as follows:

Carbon, 85 percent; hydrogen, 12 percent; sulphur, 0.8 percent; nitrogen, 0.2 percent; oxygen, 1 percent; water 1 percent.

A number of lighter oils in general use, ranging in the neighborhood of 18 to 20 degrees Baume, would average about as follows:

Carbon, 84 percent; hydrogen, 13 percent; sulphur, 0.8 percent; nitrogen, 0.2 percent; oxygen, 1 percent; water, 1 percent.

Certain heavier oils ranging from 12 to 14 degrees Baume, average about as follows:

Carbon, 86 percent; hydrogen, 11 percent; sulphur, 0.8 percent; nitrogen, 0.2 percent; oxygen, 1 percent; water 1 percent.

As a result of tests by Edmond O'Neill, professor of chemistry of the University of California, the calorific value of Bakersfield oil may be taken as about 18,600 B. T. U. per pound, allowing for the presence of about 1 percent moisture as indicated above. When corrected for moisture the net heat units per pound of oil are proportionally higher, although there is a slight loss in furnace efficiency due to the presence of moisture, inasmuch as all such water is evaporated into steam and superheated to the temperature of the escaping gases, involving an amount of heat both sensible and latent.

On the basis of the above analysis, the chemical requirements of air for complete combustion per pound of oil are as shown in Table I.

In the various text-books, the values given range from 16 to 18 pounds of air per pound of oil, but an average of 14 pounds of air per pound of oil is more nearly correct.

The ordinary method of indicating and measuring steam to atomize oil has been to express the quantity as a percentage

* From a paper presented at the December, 1908, meeting of the American Society of Mechanical Engineers.

of the actual amount of water evaporated in the boiler. This percentage ranges from about 2 to 5 and over, depending on the system of oil-burning, type of burner, etc. While such a percentage rating is no doubt convenient, it is inaccurate, in that the steam consumption of oil burners is proportional to the oil burned and not to the water evaporated. Various tests have shown that the steam consumption of oil burners ranges from 0.14 to over 0.5 pound of steam per pound of oil. The average value of good performance is about 0.3 pound of steam per pound of oil, although with hand regulation on variable load this quantity should be slightly increased, and is somewhat dependent on the gravity of the oil, temperature at the burners, etc. In stationary practice, the use of air for atomizing has been practically abandoned.

TABLE 1—WEIGHT OF AIR REQUIRED FOR COMBUSTION OF OIL OF DIFFERENT GRADES.

GRADE OF OIL.	Light.	Medium.	Heavy.
Percent of C	84.00	85.00	86.00
Percent of H	13.00	12.00	11.00
Percent of S	0.80	0.80	0.80
Percent of N	0.20	0.20	0.20
Percent of O	1.00	1.00	1.00
Percent of H_2O	1.00	1.00	1.00
Calculated air per pound of oil chemically required—pounds	14.25	14.02	13.79
Corresponding maximum percent CO_2 by volume—dry gases of combustion, percent	15.16	15.52	15.89

As no direct experiments have been made showing the loss in boiler efficiency due to various percentages of excess air supply, the writer will present some simple calculations showing the amount of this loss.

It is well known that the loss due to an excess of air supply is not only on account of the direct loss in heating the added air to the temperature of the flue gases, but there is a secondary loss, due to the fact that, corresponding to an excess of air, there results a higher flue temperature, not only for the actual amount of air necessary for combustion, but for all such excess air. Calculations as to boiler performance are simplified with oil fuel, as practically complete combustion is secured in a well-designed furnace, the carbon and carbon monoxide usually being burned to CO_2. The stack losses include the sensible heat contained in the dry gases of combustion, the sensible and latent heat in the steam from the combustion of hydrogen and oxygen and in the steam introduced through the burner, and the moisture present in air for combustion.

Assuming complete combustion, and employing a boiler radiation loss of 3 percent, the writer has calculated the boiler efficiency, at rating, for various percentages of excess air supply, as given in Table 2.

TABLE 2—BOILER EFFICIENCY FOR EXCESS AIR SUPPLY.

EXCESS AIR SUPPLY, PERCENT.	10	50	75	100	150	200
Assumed temperature escaping gases, deg. Fahr	400	450	475	490	Over 500	Over 500
Corresponding ideal efficiency of boiler percent	84.2	80.27	77.66	75.22	Under 70.94	Under 67.09
Possible saving in fuel due to reduction of air supply to 10 percent excess, expressed as percent of oil actually burned under assumed conditions	0	4.67	7.78	10.68	Over 15.76	Over 20.32

The 3 percent used for boiler rediation is subject to some variation, being greater in small boilers and less in large units. For medium units, 3 percent is probably very close.

The stack temperatures for any particular type of boiler, for any given load and corresponding to any assumed percent of excess air, will vary with the size of boiler, arrangement of heating surface, character of baffling, condition of heating surface, etc. Stack temperatures will also vary with the different types of boilers corresponding to these factors. The temperatures given corresponding to the stated air supply, from 10 to 100 percent excess, are those to be expected in ordinary practice and necessarily approximate: with boilers having three passes of gases and sinuous headers, the temperatures in general will be lower than those indicated; with boilers having but one pass and flow of gases parallel to tubes, the temperatures in general will be higher than indicated.

Very few data are available for the temperatures corresponding to 150 and 200 percent excess air, and the corresponding figures are given merely to show in a general way the magnitude of the losses easily resulting from careless firing of crude oil. The flue temperatures assumed are also subject to variation dependent on the rate of forcing the boiler and other well-known elementary factors. The excess air with careless oil burning is usually greater than with careless coal firing, because of the greater excess draft power of chimneys. In the preceding table the writer has calculated the saving that could be effected by reducing the air supply from that specified to an ideal condition assumed to correspond to 10 percent excess air. This saving in fuel is of vast importance, but has been almost completely neglected with oil fuel.

It is possible to obtain a fair notion of the percentage of excess air from a mere determination of the amount of CO_2; that is, assuming all hydrogen having been burned to H_2O and all carbon to CO_2. Any simple formula involving the element CO_2 must be dependent on an assumed percentage of hydrogen in the oil fuel, but inasmuch as the hydrogen contained is fairly uniform for any given grade of oil, there is but little error in such an assumption.

TABLE 3—POUNDS OF AIR PER POUND OF OIL AND RATIO OF AIR SUPPLIED TO THAT CHEMICALLY REQUIRED.

PERCENT CO_2 BY VOLUME AS SHOWN BY ANALYSIS DRY CHIMNEY GASES.	LIGHT OIL. C, 84 Percent; H, 13; S, 0.8; N, 0.2; O, 1; H_2O, 1.		MEDIUM OIL. C, 85 Percent; H, 12; S, 0.8; N, 0.2; O, 1; H_2O, 1.		HEAVY OIL. C, 86 Percent; H, 11; S, 0.8; N, 0.2; O, 1; H_2O, 1.	
	Pounds of Air per Pound Oil	Ratio Air Supply to Chemical Requirements.	Pounds of Air per Pound Oil	Ratio Air Supply to Chemical Requirements.	Pounds of Air per Pound Oil	Ratio Air Supply to Chemical Requirements.
4	51.40	3.607	51.93	3.704	52.45	3.803
5	41.31	2.899	41.71	2.975	42.12	3.054
6	34.58	2.427	34.90	2.490	35.23	2.554
7	29.77	2.089	30.04	2.143	30.31	2.198
8	26.17	1.836	26.39	1.883	26.62	1.930
9	23.37	1.640	23.56	1.680	23.75	1.722
10	21.12	1.482	21.29	1.518	21.45	1.555
11	19.83	1.391	19.43	1.386	19.58	1.419
12	17.76	1.246	17.88	1.276	18.01	1.306
13	16.46	1.155	16.57	1.182	16.69	1.210
14	15.36	1.078	15.45	1.102	15.55	1.127
15	14.39	1.010	14.48	1.033	14.57	1.056

Table 3 shows the calculated weight of air per pound of oil and the ratio of actual air supply to chemical requirements, for the various grades of oil and various percentages of CO_2. Under the present systems of firing, the amount of CO_2 present in the flue gases is often as low as 4 or 5 percent. With an ample supply of labor and a careful and scientific adjustment of dampers by hand, the percentage of CO_2 under an ideal and uniform load can be maintained as high as 13 percent. With automatic control and under variable load conditions it has been found possible to maintain a high percentage of CO_2 conforming very closely to ideal conditions.

The first notable step in advance of the crude systems of hand firing was at the plant of the Pacific Electric Railway Company, Los Angeles, Cal., under the direction of Mr. J. R. Atchison, then chief engineer for that company, now superintendent of construction for Chas. C. Moore & Company, engineers. Mr. Atchison developed a plan for firing eighteen boilers, averaging three burners per boiler, totaling about fifty-four burners, with central hand control of oil pressure.

The operator was stationed near the oil pumps, which were run at a practically constant speed. In front of the operator were the oil pressure gage connecting to oil main and the steam pressure gage connecting to steam main. The operator's duty was to maintain a uniform steam pressure on the boilers by opening or closing a bleeder valve on the oil-pump discharge line, thus increasing or decreasing the pressure in the oil main, and simultaneously the rate of firing of all of the boilers. The operating crew of the boiler room for each shift consisted of the one operator controlling the oil pressure and one water tender; which is probably the record to date for the minimum of boiler-room labor for any plant of this size. It was a simple matter to substitute automatic regulation for hand control, following which the writer conceived the idea of utilizing this variation in oil pressure as a secondary means for controlling the supply of steam to burners and the air supply for combustion.

A NEW METHOD FOR THE PURIFICATION OF WATER.*

With the advancing development of the industrial arts, competition also becomes continually sharper, so that the manufacturer is compelled—as much as circumstances permit—to take advantage of the tireless progress of the technical arts. It is not long since one contented himself, fatalistically, with ignoring all the disadvantages which bad feed-water caused in the operation of the steam boiler, or hard and muddy water brought about in manufacturing operations.

Twenty-five years ago there were few manufactories which softened and cleared the feed-water for the steam boiler. When this was done, it was effected principally through large receptacles, which were filled with the water to be treated, and into which were introduced soda and lime-milk or caustic soda, or soda alone, together with a considerable pre-warming. The mixture was stirred, and, for the sake of the chemical reaction and clearing, left standing for a considerable time, and then the softened and cleared water drawn off. Other so-called anti-scale means, operating chemically or mechanically, and which were directly introduced into the boilers, have already had their true values proved and their analysis published.

Up to the present time, carbonate of soda, caustic lime and caustic soda have shown themselves the best suited and the cheapest means for the transformation of the dissolved scale-forming lime and magnesium salts; and these have come almost exclusively into use. Since the introduction of continuously and automatically operating apparatus, the practice has passed from the primitive purification in large receptacles, which require great attention and a great deal of room besides being expensive, so that now only the former method is in use. The knowledge among possessors of boilers that a rational method for the purification of water is of very great advantage has induced many firms to build water purifiers.

Now, although pretty much every one of these firms has been more or less successful in providing its especial equipment with new and, for the most part, patented devices, which, in comparison with the apparatus of other works, are said to have brought about a better mixing and a more economical consumption of the chemicals, or a rapid removal of the precipitated sludge, nevertheless it cannot be maintained that one or another of the systems has succeeded, on the basis of these novelties, in driving the remainder off the market, or in making itself the only ruling system. The reason for this is that, on the one hand, with every apparatus, even of the older process, a sufficiently good and cheap purification may be secured, in so far as that apparatus conforms merely to the general conditions of construction relating to the art of water purification; while, on the other hand, certain evil effects, called forth by the purification and growing out of the chemical occurrences, are not removed even through the later devices.

With the process, hitherto customary, in the use of calcined and caustic soda separately, or in combination with each other, or with caustic lime, the salts remaining pass into the boilers. In order that these may not reach too strong a degree of concentration, the boiler water must be, now and again, drawn off and replaced by fresh water. The exudation of sulphate of soda at the fittings and rivet holes are an unpleasant incident, which, up to the present, has had to be reckoned with. A real advance in the province of the art of water purification is, therefore, scarcely to be expected, so long as one limits himself to altering the apparatus in form of construction, or even to improving it, but retains in other respects the former procedure.

Among those who are concerned with this department, a new process of water purification by means of carbonate of baryta, by virtue of which the above-mentioned evils are avoided, has, therefore, awakened considerable attention. This rests upon the fact that the finely pulverized carbonate of baryta transposes itself very energetically with the sulphate of lime contained in the water, and in such manner that sulphate of baryta and carbonate of lime are formed, both of which are insoluble in water and, on that account, are precipitated as sludge. Thus the very important phenomenon comes to light—that not only the sulphate of lime, which was dissolved in the water before its purification, and which appears in the boiler as a scale former, is precipitated, but also the chemicals occasioning its precipitation. For this purpose it is requisite that a corresponding and sufficiently large mass of carbonate of baryta be present, through which the water to be purified is passed. To accomplish this it is added in pulverized form, and in considerable excess—in most cases sufficient for several months—and thus without mixing.

This is carried on in the receptacle for reactions and clarification belonging to the apparatus constructed for this process. In the lower conical part of this the water to be purified enters by fits and starts. By this means is brought about a continually renewed whirling up of the baryta, and the sulphuric acid contained in the water is completely bound by it. In the upper part of the purifier the water passes through a filter, in which all the sludge particles which may have been carried along are retained. These are, from time to time, washed back into the bath of baryta—for one thing to avoid the loss of baryta and for another to cleanse the filter. In order to free the water from carbonates, caustic soda is employed, which is dissolved in a continuously-operating Dervaux lime saturator, and led to the reaction receptacle.

In connection with the devices already carried out, and which have been in operation for two years, for this kind of water, it has become manifest that a renewal of the carbonate of baryta, according to the hardness of the water, is necessary only every one to four weeks. The drawing off of the sludge, on the contrary, need be carried out at most only every three months. The current expense is frequently less—but usually not higher, or but slightly higher—than with the soda-lime process. But if one takes into consideration the advantages of the new process, then this slight increase in cost vanishes. For since, with the tranformation of the sulphates, none remains in solution, even the troublesome exudation of sulphate of soda ceases, which (if allowed to continue) causes not merely the ruin of the fittings but also other evils—as, for instance, increase of the specific gravity of the boiler water, and increase of the boiling point, resulting in a reduction of a saving of fuel. Extremely hard water cannot be softened through treatment by means of carbonate of soda, apart from excess of the same, and very considerable pre-warming, to the extent that it passes on without an after-reaction in the boiler as well as on the way to it. And so deposits are made

* Translated from *Maschinen und Metallindustrie-Zeitung.*

in the piping, pre-warmer and injector. These cannot arise with the purification by means of baryta, any more than can foaming of the boiler water, which, especially in locomotives, is so important on account of the so-called "spitting."

In the case of the presence of corroding substances in the water—for instance, chloride of magnesium, which is not present in all waters and, for the most part, only in exceedingly small quantities, and upon which baryta exercises no influence—a breaking up of the chloride of magnesium into magnesium hydrate and common salt is brought about by the addition of suitable chemicals. It is thereby made completely harmless, so that no corrosion can arise. It may be added that carbonate of baryta cannot be applied in the place of the carbonate of soda without further ado, but that there is needed for this purpose an especial arrangement in the apparatus for the purification of the water. But water purifiers of almost every sort can easily be modified for this purpose. The new process is patented.

BOILERS OF THE LAKE STEAMER CITY OF CLEVELAND.

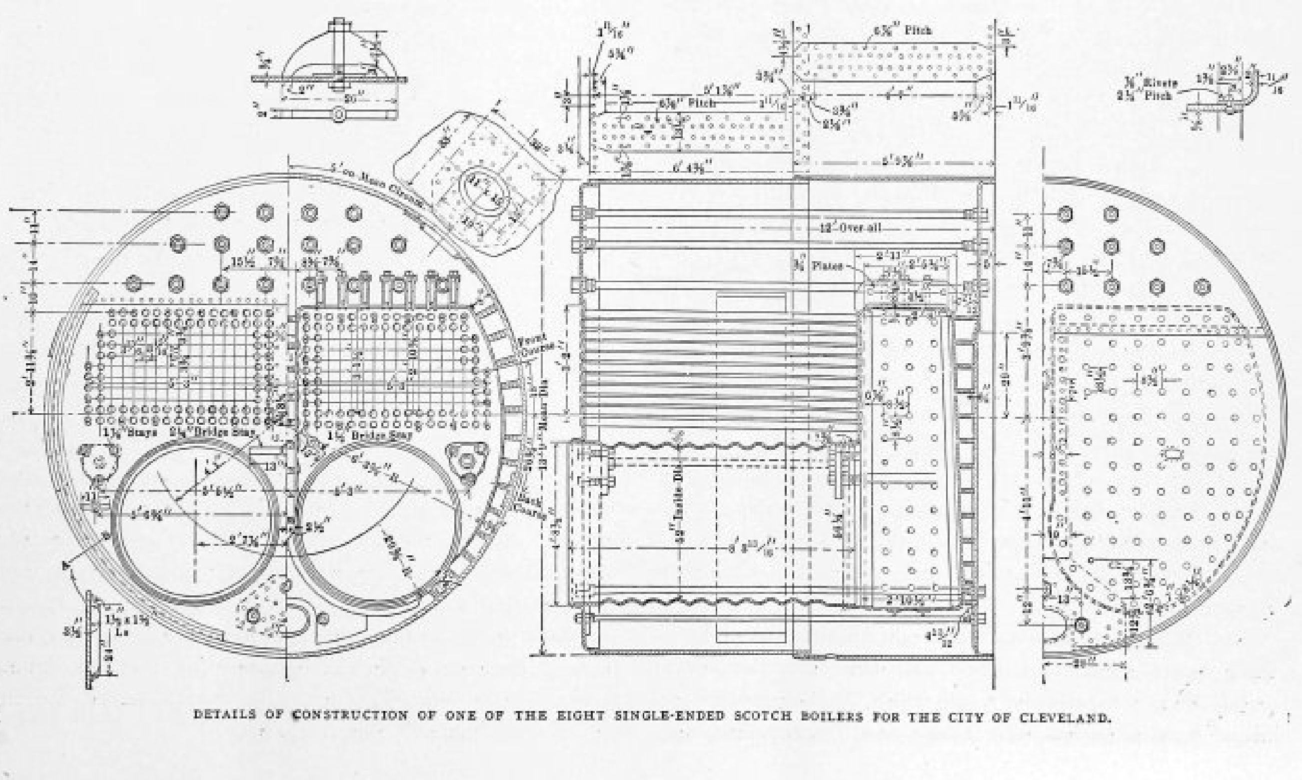
A new lake passenger steamer, the *City of Cleveland*, designed by Frank E. Kirby, naval architect, Detroit, has recently been built by the Detroit Shipbuilding Company for the Detroit & Cleveland Navigation Company. The boat is a steel paddle-wheel steamer, 404 feet long over all, with a beam of 54 feet, a depth of 22 feet and a gross tonnage of 4,568. The propelling machinery consists of three-cylinder inclined compound engine, driving feathering paddle-wheels 29 feet in diameter. The high-pressure cylinder is 54 inches and the two low-pressure cylinders 82 inches in diameter, with a piston stroke of 8 feet. On her official trial trip a speed of 20 statute miles per hour was obtained, with an average horsepower of 5,717. With this speed the number of revolutions per minute were 27.6.

Eight cylindrical boilers are provided, located in two separate compartments. Their diameter is 13 feet 9 inches, and length 12 feet, each being provided with two Morison suspension furnaces, 52 inches in diameter. The working steam pressure is 160 pounds per square inch. The boilers are worked with the Howden hot-draft system. Two smokestacks are fitted.

Each boiler has a shell in two courses, each course being made of two plates 1 7/64 inches in thickness. The design of the seams shows a plate strength of 80.9 percent of the uncut plate, and a rivet strength of 80.35 percent. Details of riveting are shown on the drawing. In the upper part of the boiler are eighteen through steel stays in three rows; the upper row has stays measuring 2⅛ inches in the body and 2½ inches in the screw ends; the others are 2½ inches in the body and 2⅞ inches in the ends. In the region below the furnaces are three through stays measuring 2 and 2⅜ inches respectively, with bridge stays between the furnaces and the nests of tubes, measuring 2¾ and 3 inches. The staybolts, in connection with the combustion chamber, are 1½ inches in diameter, and have 10 threads per inch.

Each boiler contains 360 tubes, with an outside diameter of 2¾ inches. Of this number, 324 are ordinary tubes of No. 12 B. W. G.; the remaining 36 (marked "S") are stay tubes of No. 7 B. W. G. These latter are thickened at both ends to 3 inches and screwed through both tube sheets. The tube sheets are ¾ inch thick in front and 11/16 inch in back. The distance between sheets is 7 feet 11 inches. The back of the combustion chamber is ⅝ inch thick, while the boiler heads, which are flanged, are 1 3/64 inches.

A novel circulating device is arranged, as shown on the drawing. A sheet steel box, 24 by 3½ inches, made of 10-pound plate and angles 1½ by 1½ inches, is attached to the shell of the boiler on each side about midway between the tube sheets. This box starts at the bottom of the boiler and extends to about the location of the waterline. The idea is for water to flow down through these boxes, and thus create a better circulation than would naturally exist through the nest of tubes, unaided by such a device.



DETAILS OF CONSTRUCTION OF ONE OF THE EIGHT SINGLE-ENDED SCOTCH BOILERS FOR THE CITY OF CLEVELAND.

The Boiler Maker

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NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

The edition of this issue of The Boiler Maker comprises 5,500 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

Municipal Boiler Inspection.

Following the example recently set by the State of Massachusetts, several cities are now contemplating the revision of their statutes governing steam boiler inspection. In all of these cases, so far as we know, it is the intention to provide a set of rules governing boiler construction and inspection which shall adequately meet the requirements of modern practice in boiler making. As a pattern, the Massachusetts rules will be found excellent to follow if a few minor changes are made. The specifications for boiler plate should be made to conform with the specifications of the American Boiler Manufacturers' Association, as these represent a higher standard than those embodied in the Massachusetts rules. There is no good reason why the percentage of phosphorus and sulphur should not be limited to .04 percent in flange or boiler steel and .035 percent in fire-box and extra soft steel, with the possible exception of flange or boiler steel made by the acid process in which .06 percent phosphorus is usually allowed. There is really, however, no good reason why a greater percentage of phosphorus should be allowed in acid steel than in that made by the basic process, except that it is harder to get the phosphorus out of acid steel than it is to get it out of the basic. Since, however, it is by no means impossible to produce flange or boiler steel by the acid process with a percentage of phosphorus as low as .04, this requirement should be insisted upon.

It is encouraging to note these indications of progress towards better boiler construction and boiler inspection in our cities. This is exactly the result which the Boiler Manufacturers' Association has been endeavoring to accomplish, since finding that it is well nigh impossible to secure uniform State laws covering boiler inspection. These reforms cannot be carried too far to insure the safety of life and property, which everyone has a right to expect from our municipal governments. With Canada awakening to the fact that uniform legislation is needed to regulate the construction and inspection of boilers, and with several of the largest cities in the United States revising their statutes to provide adequate legislation on this subject, there is every reason to believe that the coming year will show marked progress towards better conditions regulating the construction, installation and operation of steam boilers.

Cost of Welding Flues.

With the advent of the oxyhydric and oxyacetylenic method of blow-pipe welding, a cheap method is afforded for welding certain work which cannot be handled in the old-fashioned way. The cost of either of these processes is, however, apparently greater than that of the ordinary method of welding in cases where the ordinary method can be used to advantage. In France, safe ends are welded on flues by the oxyhydric process, and some figures are available showing the cost of this work. The average time taken for welding a flue is five minutes, so that an average day's work for one man, working ten hours per day, is about 120 flues per day. The cost per tube for labor, including cleaning, cutting down old tubes, sawing off and chamfering the new ends, welding, straightening, testing, etc., is 6½ cents per tube; while the gas costs about 1½ cents per tube, making the total cost per tube about 8½ cents.

At a recent convention of master blacksmiths in the United States a case was cited where one man, without a helper, welded in the ordinary way 350 to 400 tubes per day, hauling the tubes from the rattler to his welder, heating, scarfing and welding the flues, and finally delivering them to the boiler shop himself. For this labor he was paid a cent and a half per tube. This, of course, is an extreme case, and there are probably few men welding flues who can turn out from 350 to 400 per day, but almost any workman can easily weld 200 flues per day, taking them after they are removed from the locomotive, cleaning them in the rattler, welding and putting them back in the engine. This is being done regularly on at least one large railroad, and the cost of the labor is about 1 cent per tube. Of course, to compare this with the cost of welding by the oxyhydric process it would be necessary to add the cost of the oil used in heating the flues; but this is such a small quantity that it would not greatly affect the result. The ordinary method of heating flues in an oil furnace and welding them in a roller or pneumatic welding machine is undoubtedly far cheaper and quicker than any other method which has been devised. At best, however, it is no small item in the cost of maintenance of locomotives, especially in bad-water districts, where the life of flues is comparatively short. In estimating the cost of flue work, not merely the cost of the actual labor and material used in replacing the flues must be considered, but to this must be added the loss of the earning power of the locomotive, which, as an average, may be taken as six or seven hundred dollars per day.

Convention Announcement.

The annual convention of the International Master Boiler Makers' Association for 1909 will be held at the Sealbach Hotel, Louisville, Ky., April 27, 28, 29 and 30. The hotel has made the following rates: European plan, single room, without a bath, $2 per day; two in a room, $3 per day; $1.50 extra for each additional person in the above rooms. Rooms with a bath, one person, $3, $3.50 and $4; two persons, $4, $4.50 and $5. Any person desiring American-plan rates will find several first-class hotels within a radius of one or two blocks.

Spacing Holes in a Patch.

EDITOR THE BOILER MAKER:

In the November issue of THE BOILER MAKER appears an article on patching a boiler. I am of the opinion that if this paper template rule was followed in practice on a round shell you would not have very fair holes, as you would have to allow for the take-up in rolling the patch, and it is absolutely necessary to have fair holes for patch bolts. The writer employs the following method:

Take a rivet that will fit snugly in the holes already in boiler; grind the head down to the thickness of the iron of which the patch is to be made, and put a light center mark on the center of the head; then set a pair of dividers to any convenient length; put the rivet in a hole, and with one leg of the dividers in the center of the rivet strike an arc. Move the rivet to the next hole and strike an arc crossing the first arc. Repeat this for all the holes, then put a light center mark at the intersections of the arcs. Put the patch up, making sure that it fits reasonably well, and hold it in any convenient way. Then by using as centers the intersections of the arcs, and with the same radius, you can now strike arcs on the patch, the intersections of which will be the proper centers for the holes in the patch. With a reasonable amount of care perfect holes can be secured in this way. A. E. C.

Boiler Inspectors.

EDITOR THE BOILER MAKER:

When the bill creating the office of boiler inspector was passed in Chicago back in the 60's, the first man to get the position was a hatter, the next was a carpenter, then the boiler makers got busy and had the law changed so that the inspector must be a practical boiler maker, and it has held that way ever since. It is the same in Kansas City and St. Louis. In Omaha the boiler inspector must be a mechanical engineer. That is what the ordinance says, but in practice he must be a political engineer. From 1895 to 1898 a man held the job of boiler inspector in O—— who had been a butcher. He was a glib talker and got into politics. A boiler maker called on him once for a certificate to run a stationary engine. The inspector turned him down, saying that because a man could construct a boiler he was not necessarily competent to run one. It would seem that in some places in order to get a license a man must learn to cut a steak or patch a shoe, or do some highly scientific job like that.

THE MAN FROM MISSOURI.

Patching Side Sheets.

EDITOR THE BOILER MAKER:

When Mr. Jewell tells of a method of patching side sheets of a locomotive fire-box, he is correct as far as leaving out the copper gasket, but if he spaces his holes 1⅝ to 1¾ inches for ¾-inch patch bolts he will be sure to have a better job. Also make the inside lap ¾ inch from the center of the hole, and the outside lap ⅞ inch. Instead of using a pattern, put the patch in place and drill through it. Then if you are rushing the job save the burrs that are punched out of the patch; drive them into the holes on the anvil, and punch over again with a 25/32-inch punch. Get the patch countersunk, and take time to put it in the fire. Let it stay in the fire, well covered, over night; you will then have a piece of steel that will work like copper. SUBSCRIBER.

Leaky Flues.

EDITOR THE BOILER MAKER:

I believe Mr. Doarnberger has got something new in his auxiliary flue sheet which will be a grand thing in districts where there is good water and the flues run eight or ten years without renewing. But in bad-water districts, where you have to renew the flues at least every year, sometimes oftener, it will not take very well. As far as I know, some flues have always leaked more than others, and there is always a reason for it. One is, that a man who is no good in any other place around a boiler shop is always made a flue setter; another reason is, dumping fires at the clinker pit with the blower going full blast. Let some of the experts devise a way to remove the clinkers, ashes, etc., from the pits in the roundhouse, and put the engines in the house with the fire in. Let the fire stay in the fire-box when the engine is wanted again in six or eight hours. After coming in, clean out the fire-box and start a new fire. This may not cure leaky flues, but, if it is tried, there will not be so many leaky flues. F. P.

PERSONAL.

J. E. JOHNSON, master boiler maker of the Texas & Pacific Railroad, at Big Springs, Tex., died on November 6.

WILLIAM LA GRANGE, one of the boiler makers of the Norfolk & Western Railroad, died recently as the result of burns received while making repairs in the fire-box of a locomotive.

FRANK P. JENKINS and WILL J. BURNETT have recently established a new boiler shop in Chattanooga, Tenn., the name of the corporation being the East Tennessee Boiler Manufacturing Company.

CHIEF ENGINEER JOHN PATTERSON, of Manistee, Mich., and three other men were scalded to death by the explosion of a steam pipe aboard the steam barge *Maggie Marshall*, on Oct. 20.

P. J. CONRATH, formerly traveling boiler inspector for the Missouri-Pacific Railroad, has been appointed master mechanic for the St. Louis, Iron Mountain & Southern Railroad, with headquarters at De Soto, Mo. Mr. Conrath is well known to boiler makers as president of the International Master Boiler Makers' Association.

L. BORNEMAN, formerly foreman boiler maker of the M. K. & T. shops at Denison, Tex., has recently been made master boiler maker of the Chicago, St. Paul, Minneapolis & Omaha Railroad, with headquarters at St. Paul. Minn. For several years Mr. Borneman was in charge of the Cincinnati, Hamilton & Dayton shops at Indianapolis, Ind.

AT A CONVENTION of the Canadian Manufacturers' Association, recently held in Montreal, Que., Mr. Leonard, of London, Ont., presented a special report relating to the boiler manufacturing industry, under the head of "Uniform Boiler Inspection." The result of this paper has been to arouse a desire on the part of the manufacturers for uniform boiler inspection throughout Canada.

H. P. COBURN, vice-president and manager of the Sawyer-Massey Company, of Hamilton, Ontario, Can., died November 25. Mr. Coburn was 73 years of age, and for the greater part of his life was connected with the Sawyer-Massey Company, formerly as one of the firm of L. D. Sawyer & Company and later as vice-president and general manager of the present corporation.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—Is there any convenient formula for estimating the weights of marine boilers from known data of the boilers? Y. K. N.

A.—A paper read in 1897 before the Society of Naval Architects and Marine Engineers, gives formulas for Scotch, low cylindrical and locomotive boilers, including their respective mountings. Separate formulas are given for water in these boilers. The formula in each case covers one boiler only.

For single-ended Scotch boilers, the weight in tons (2,240 pounds) is $0.0075\ [D^2\ (L + 2) + H.\ S.] + 1.5$.

For double-ended Scotch boilers, weight $= 0.0075\ [D^2\ (L + 2) + H.\ S.]$.

For locomotive boilers, weight $= 0.0075\ [D^2\ (L + 2) + H.\ S.] - 1.5$.

For single-ended low cylindrical boilers, weight $= 0.005\ [D^2\ (L + 2) + H.\ S.] + 8$.

For double-ended low cylindrical boilers, weight $= 0.005\ [D^2\ (L + 2) + H.\ S.] + 6.5$.

For water in the main boilers other formulas are used. In Scotch boilers, with water 8 inches above the top row of tubes, the weight $= 0.0117\ (D^2\ L - A)$.

In low cylindrical boilers, with water 6 inches above top row of tubes, weight $= 0.01\ (D^2\ L - B)$.

In locomotive boilers, with water 6 inches above the furnace crown, weight $= K\ (D^2\ L - C - 125)$.

For auxiliary boilers, including contained water, the weight, for both horizontal and vertical types, may be placed at $0.031\ D^2\ L$.

In the above formulas the following notation is used:

D = Mean diameter in feet.
L = Length over end plates in feet.
$H.\ S.$ = Total heating surface of the boiler in square feet.
$T.\ S.$ = Tube heating surface in square feet.

$$A = \frac{H.\ S. \times d}{12\ \pi} + nf^2\ l.$$

$$B = \frac{H.\ S. \times d}{12\ \pi} + nf^2\ (L - l).$$

$$C = \frac{T.\ S. \times d}{12\ \pi}$$

d = Diameter of tubes in inches.
l = Length of tubes in feet.
f = Maximum diameter of furnaces in feet.
n = Number of furnaces in one boiler.
K = 0.028 for boilers with dry bottom and one furnace; 0.03 for two furnaces; 0.032 for boilers with wet bottom and one furnace, and 0.034 for two furnaces.

It will be noted that the tons per inch at above levels of water will be approximately $0.0021\ D\ L$.

These formulas are part of a large number, going into the estimated weights of machinery for both warships and merchant steamers. They have been computed from the recorded detail weights of machinery of more than three hundred vessels, embracing almost all of the types found in service, and have been found to give very close results in practice. In a number of cases, where Scotch, locomotive and low cylindrical boilers were fitted, the estimated weights of machinery complete were found to come within 3½ percent of the actual recorded weights. In computations for 115 separate ships there were only eleven cases where the error exceeded the above percentage.

TECHNICAL PUBLICATIONS.

Steam Boilers. By Prof. C. H. Peabody and Edward F. Miller. Size, 5¾ by 9 inches. Pages, 420. Figures, 175. New York, 1908: John Wiley & Sons. Price, $4.

The former edition of this book, published in 1897, has become so well known as a standard textbook on the subject of steam boilers that little need be said regarding that part of the book, which is a repetition of the former edition. In the new edition a considerable amount of new material and many new illustrations have been added. While the number of subjects treated, and the order in which they are taken up have not been greatly changed, yet each chapter has been added to and revised to bring the work up to date. A chapter has been added on superheaters, in which the various types of superheaters now in use are illustrated and described. The best materials for use as steam-pipe fittings for superheated steam are considered. Considerable additional matter is given on the subject of steam piping, including the strength and expansion of pipe, the bursting point of extra heavy flanged fittings, the area of steam pipes, the flow of steam in pipes, and, finally, pipe coverings. A number of valuable tables, giving the dimensions and floor space occupied by different types of boilers and of economizers, have been added to the appendix. Other valuable features of the book include a comprehensive treatment of the subjects of fuel and combustion, corrosion and incrustation, a detailed description of the method of testing boilers, including gas analysis, measurement of air used, temperatures, etc. The principles and methods explained in the early chapters of the book are finally brought together and illustrated by applying them to the complete design of a horizontal tubular boiler.

The Boiler. By Stephen Christie. Size, 6 by 8¾ inches. Pages, 264. Figures, 15. Chicago, 1908: Christie Publishing Company. Price, $2.50.

This book will be appreciated by practical boiler makers who wish to see the various calculations necessary in designing and building a steam boiler worked out in detail. Examples are given to illustrate all calculations described in the book, and the numerical work in each case is given in full.

The first chapter describes in detail the various materials used in boiler construction, giving the usual specifications for the manufacture and testing of such materials. Chapter II describes the method of selecting a suitable boiler for a certain engine power. Following this the details of construction are taken up, and various rules for the strength of flat plates, braces, flues, furnaces, etc., are given. An entire chapter is devoted to a discussion of the strength of the lap-riveted joint and another chapter to a discussion of the butt joint.

The final chapters of the book take up miscellaneous subjects, such as boiler settings, chimneys, tests and inspection, feed water heating and purification, pumps and tanks, and rules for the care and operation of steam boilers. The book is replete with valuable tables covering most of the data which a designer will need for daily use.

Steam Boilers. By W. S. Newell and C. S. Dow. Size, 6½ by 9½ inches. Pages, 75. Figures, 69. Chicago, 1909: American School of Correspondence. Price, $1.

Special stress has been laid in this book on the practical side of each subject, as distinguished from the theoretical or academic discussion. The book is in two parts, one taking up the construction of boilers and the other describing different types of boilers. The authors, who are practical boiler makers, have paid particular attention to details of construction and shop operations, omitting detailed mathematical calculations. In describing different types of boilers the various attachments and appurtenances which are necessary to complete an installation are described. The different types of boilers are classified according to their use as stationary, marine and locomotive, and according to form of construction as flue, firetube, watertube and mixed types.

The Proper Distribution of Expense Burden. By A. H. Church. Size, 5⅛ by 7⅝ inches. Pages, 116. New York and London, 1908: *The Engineering Magazine.* Price, $1.00 and 4/-.

This is a contribution to the much-vexed question of correct cost accounting, and represents a series of articles on the subject, which first appeared in *The Engineering Magazine.* The correct distribution of the expense burden is a very important and difficult problem, and mistakes in this distribution have led to very frequent disaster. The analysis conducted in this volume is simple but thorough, and such as to appeal to the common sense of the reader. Broad principles are laid down by which safe and reliable figures may be obtained for machine, piece and job costs. These principles will properly distribute all expenses of manufacture, marketing and management, so that the truth may be known as to the profit or loss of any line of product, and the cause of any change in manufacturing cost may be instantly detected.

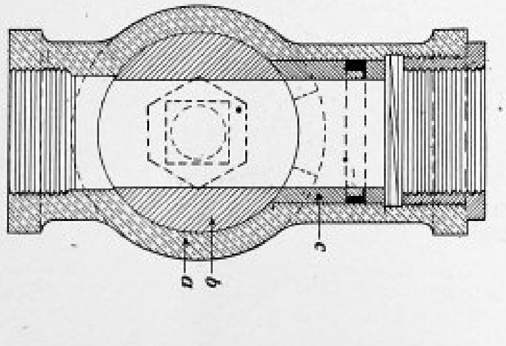
The work is divided into six chapters, as follows:

Interlocking General Charges with Piece Costs; Distributing Expense to Individual Jobs; the Scientific Machine Rate and the Supplementary Rate; Classification and Dissection of Shop Charges; Mass Production and the New Machine Rate; Apportionment of Office and Selling Expense.

ENGINEERING SPECIALTIES.

The Caskey Valve.

A new and unique valve, which can be used for several purposes, has recently been placed on the market by the Caskey Valve Company, Philadelphia, Pa. The valve may be used as a boiler blow-off drive, a hydraulic-operating valve, or as an air and relief valve. It is designed to maintain a pressure up to 10,000 pounds per square inch, and becomes more effective



as the pressure is increased. Of course, the valve is made in different weights and in slightly different form for the various purposes for which it may be used; but in all cases the valve is a straight-through valve, with no pockets or recesses. Furthermore, there are no stuffing-boxes, valve seats and, consequently, no fluttering action. The illustration shows a sectional view of the boiler blow-off valve. It consists of the body, *A;* straight plug, *B;* the bushing, *C;* ground to fit the plug, *B;* while to assure contact between *B* and *C* a spring is provided. The valves are made in sizes ranging up to 6 inches.

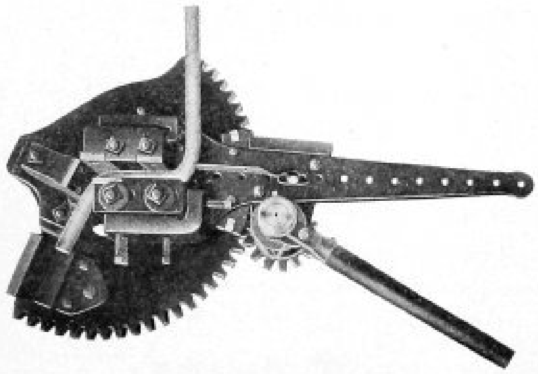
The American Inspector's Outfit.

This outfit, which is manufactured by the American Steam Gauge & Valve Manufacturing Company, Boston, Mass., consists of a 3-inch test gage of 300 pounds' capacity, a screw test pump, a hand puller, a hand set, pliers and screwdriver. All

of the instruments are nickel-plated and packed in a morocco velvet-lined case, the total weight of the outfit being about 6 pounds. Thus it can be easily carried about and is always ready for use. The outfit is especially designed for a portable testing apparatus for testing locomotive and other boiler gages, and meets the requirements of government, power plant and boiler insurance inspectors.

New Machine for Bending Rods or Bars.

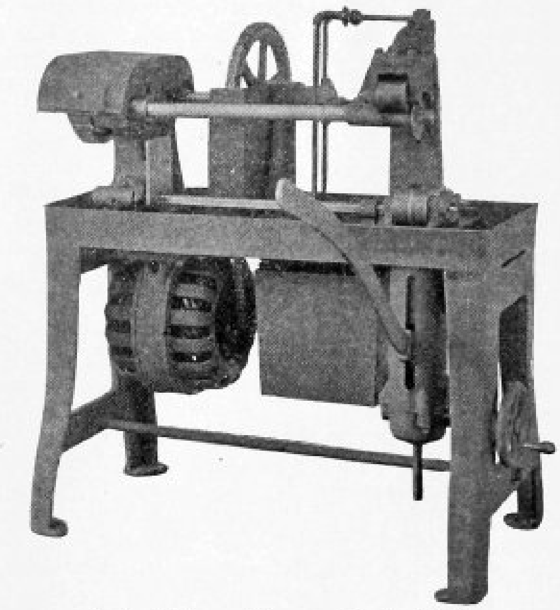
The Wallace Supply Company, 19 South Jefferson street, Chicago, Ill., has recently brought out a new tool known as their No. 4 angle bender. This machine ought to prove a very valuable one for manufacturers who have not convenient facilities for heating rods before bending, as the tool has a capacity for bending cold stock up to one inch in diameter, either square or round, or flat stock ½ x 4 inches. The machine has an auxiliary ratchet and lever which operates a pinion engaging a circular rack on the frame of the machine at a ratio of 4 2/3 to 1. Great power is obtained, while still making rapid handling possible on smaller work by providing two means of operating the bending dies. For small work the bending is done by hand. For heavier work the gear and pinion connection is operated by a ratchet and lever, thus giving increased power. The net weight of the machine is



about 235 pounds. It is secured in place by means of a socket, from which it may be removed when not in use. Set screws are employed for adjusting the size for any thickness of stock to be bent. The dies are faced with tool steel and the lever is supported by anti-friction rollers.

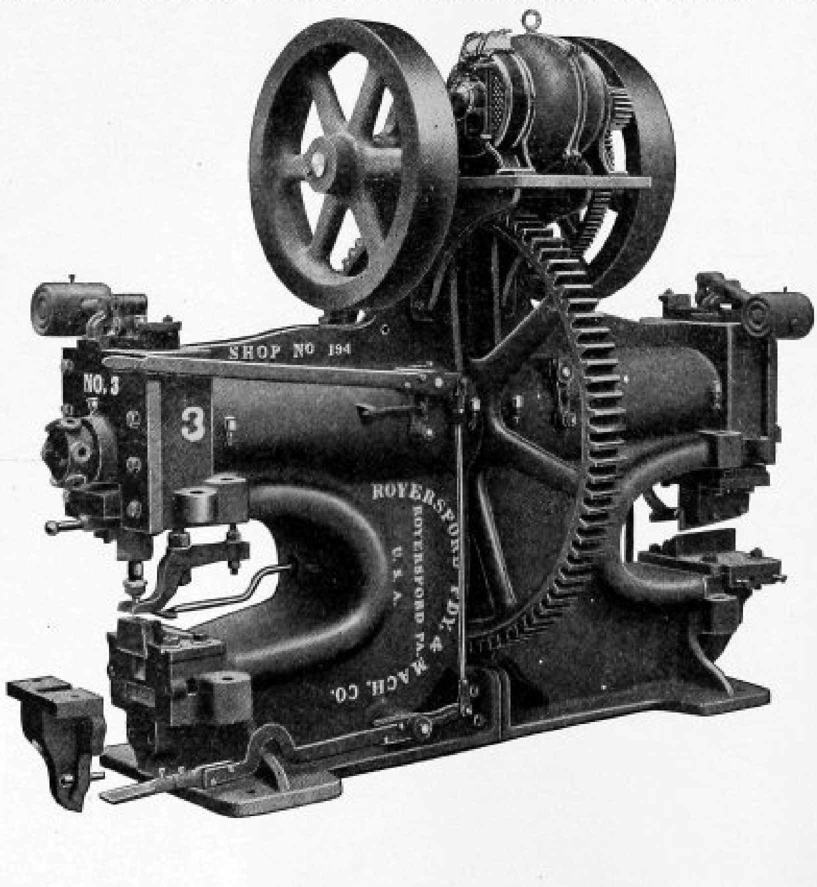
A Combination Punch and Shear.

The Royersford Foundry & Machine Company, Royersford, Pa., have on the market a combination punch and shear designed especially for railroad, boiler and structural shops. These machines are made in sizes, with either 26 or 32-inch throats, for both the punching and shearing sides. A 4-inch extension is provided on the punch side for light work, with a capacity up to a 1-inch hole through ¾-inch plate. Thus by use of the extension a depth of throat of 30 or 36 inches may be obtained on the punch side. Without the extension the punch has a capacity for a 1½-inch hole through a 1-inch steel plate. The shears have a capacity for shearing 8 by 1-inch flats or 2-inch round bars. The main shaft is made in two parts, so that each side is independent of the other, or both may be operated together if so desired. The lower jaw on the punch side is removable, which makes it convenient for punching I-beams or channel bars. The machine is strong, compact, and requires little floor space. With the 26-inch throat it weighs 18,000 pounds, and with the 32-inch throat 21,500 pounds.



Motor-Driven Pipe or Tube Cutter.

Machines for cutting off pipe or boiler flues are often placed in a pipe shed or any location where power from a line shaft is not available, so that a motor drive becomes especially advantageous. The motor-driven pipe-cutting machine illustrated is the well-known No. 6 Fox pipe or tube cutter equipped with a 3 horsepower Westinghouse motor, type



C. C. L. alternating current for 440-volt circuit, 60 cycle, 3 phase. It will be noticed that the machine with motor drive is very compact in arrangement, and the motor is mounted with practically no change from the standard machine except that the bed is provided with two pads for bolting the motor on and in place of the regular tight and loose pulleys is placed a large sprocket for the Morse silent chain drive. Power from the motor is transmitted through the Morse silent chain and a series of gears to the cutter shaft. The flue to be cut rests on the two rollers under the cutting disc and the hand wheel shown below adjusts the position of the rollers for different size pipe or flues. The cut is accomplished by depressing the lever which raises the rollers, bringing the flue against the cutter disc and severing it in a very short space of time; in fact, 1½-inch standard wrought-iron pipe can be cut in about three seconds in this manner, or a 4-inch boiler flue in about eight seconds. It will be noticed that the machine is regularly equipped with an oil pump and tank for supplying the lubricant to the cutting disc.

These machines are manufactured by the Fox Machine Company, Grand Rapids, Mich.

SELECTED BOILER PATENTS.

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

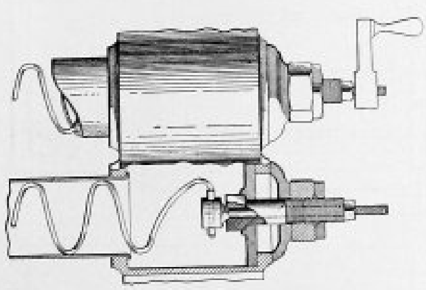
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

901,301. STEAM BOILER. John N. Leach, of Melrose, Mass., assignor of one-half to Judson L. Thomson Manufacturing Company, a corporation of Maine.

Claim.—A steam boiler, comprising in its construction a plurality of units, each of said units comprising an outer tube and an inner tube, means connecting said units together to form a series of sections, a header, and a plurality of union couplings connecting said sections, respectively, to said header. Eight claims.

902,315. BOILER-TUBE CLEANER. Eugene J. McCarty, of Clinton, Mass., assignor to the Clinton Specialty Manufacturing Company, a corporation of Massachusetts.

Claim.—The combination with a tube, of a hand-hole cover for the tube concentric therewith, a hollow bushing passing through the hand-hole cover extending inside thereof and having a head located in a recess in said cover, a shaft journaled in said bushing and having a head inside the cover adapted to bear against said bushing head, a



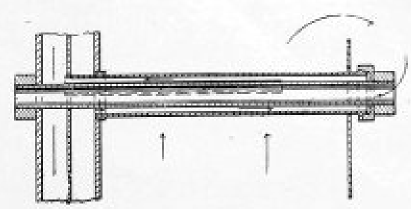
cleaning device connected with said shaft head and extending into the tube, the axes of the tube-cleaning device and bushing being in the same line, and means outside the cover for rotating said shaft and cleaning device. Five claims.

902,283. BOILER FEEDER. Norman English, of Detroit, Mich.

Claim.—In a boiler feeder, in combination with a steam boiler and a system of steam heating pipes supplied thereby, a well into which said pipes drain, a tank located above the boiler and adapted to empty thereinto by gravity, a pipe connecting said well and said tank, an overflow pipe from said tank, a receptacle into which said overflow drains, a valve in said overflow pipe controlled by said receptacle as a weight, a valve in the steam pipe adapted to control the admission of steam into said tank and itself controlled by said receptacle as a weight. Two claims.

902,740. BOILER. HANS O. KEFERSTEIN, OF NEW ORLEANS, LOUISIANA.

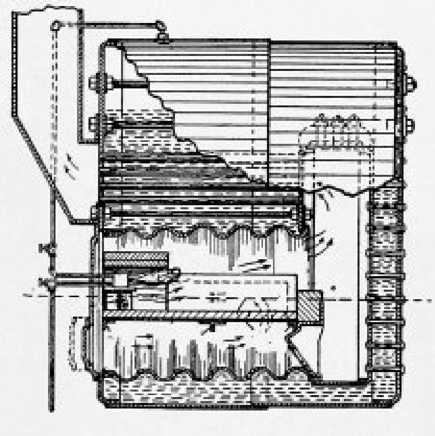
Claim 1.—The combination, with a front header provided with a steam chamber and a water chamber arranged side by side, and a rear header; of a fire tube having its end portions projecting through the said headers, a water and steam tube encircling the said fire tube and having its upper part connected with the said steam chamber and having its lower



part connected with the said water chamber at one end, and means for closing the other end of the said water and steam tube. Six claims.

902,893. INTERNALLY-FIRED BOILER. THOMAS C. MASON, OF LOS ANGELES, CAL., ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, TO MASON SMOKELESS COMBUSTION COMPANY, INCORPORATED.

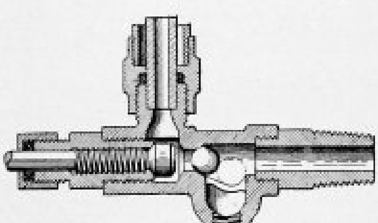
Claim.—As an oil-burning apparatus, an internally-fired boiler, a partition in the fire box thereof dividing the same into an air chamber below, and a combustion chamber above said partition, a damper at the bottom of the air chamber, horizontal flues at each side of the combustion chamber, the partition having apertures connecting one end of the



flues with the air chamber, two partly-spaced arches at one end of the combustion chamber, the other end of the flues communicating with the space between the arches, a burner located in the combustion chamber under the arches, and a transverse flue connected at each end with the space between the arches and having an outlet beneath the burner whereby heated air is discharged beneath the flame from the burner. One claim.

902,894. WATER-GAGE. CHRISTOPHER J. MATTHEWS, OF GRAND RAPIDS, MICH.

Claim 3.—A water gage for steam boilers provided with a suitable gage glass, a chamber out of the line of the gage glass between the same and the boiler, said chamber communicating with the gage glass through



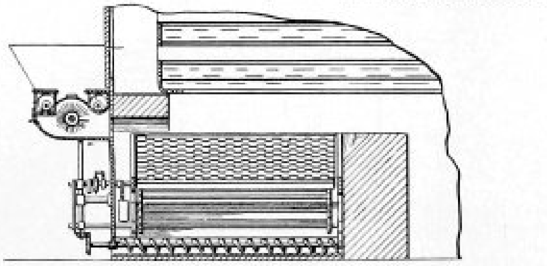
a port having a valve seat on the chamber side, another chamber or pocket below the first-named chamber, an inclined track leading downward from the said valve seat, the said track consisting of two members spaced apart with the upper surfaces inclined upwardly and outwardly in a lateral direction, a blow-off valve leading from the pocket, and a ball valve normally carried by the track. Three claims.

903,781. BOILER. JAMES J. ROHAN, OF ST. LOUIS, MO.

Claim 1.—The combination with a fire tube boiler arranged in a boiler setting, of a pair of mud drums arranged at the sides of the fire box of the furnace, a pair of vertically disposed water legs connecting each end of the boiler with the mud drums, a pair of transversely disposed headers arranged over the fire-box, the front one of which headers is connected to the front pair of water legs, tubular grate bars connecting the headers, a series of water tubes connecting the boiler with the mud drums between the water legs, which water tubes are provided with transversely bent portions which extend beneath the boiler over the tubular grate bars, and a fireproof partition extending rearward from the boiler front immediately over the tubular grate bars, which fireproof partition is supported by the transversely bent portions of the water tubes. Five claims.

903,131. STOKER. THADDIOUS V. ELLIOTT, OF NEW YORK, N. Y., ASSIGNOR TO MARIEA ELLIOTT, OF FLATBUSH, NEW YORK.

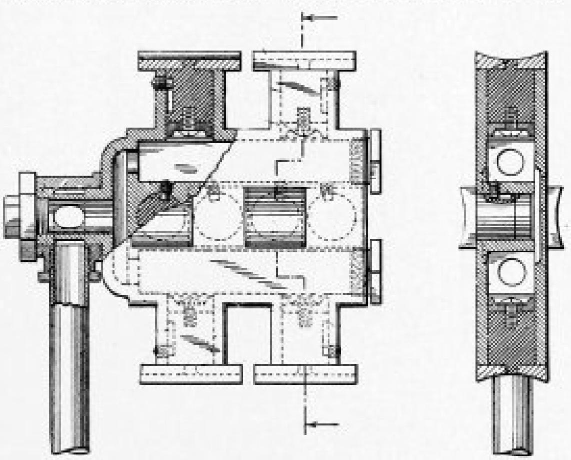
Claim 1.—A stoker comprising the following instrumentalities in combination, viz.: a fuel supply, a fuel conveyor for conveying the fuel from



the said supply and delivering it to a place of discharge, a delivery device for moving the fuel from the said place of discharge onto the grate, a grate having movable grate bars, an ash remover, and means for simultaneously actuating the fuel conveyor, the delivery device, the grate bars, and the ash remover. Thirteen claims.

903,550. TOOL FOR SPREADING THE TUBES OF WATER-TUBE BOILERS. JOSEPH F. DUGETT, OF NEW YORK, N. Y.

Claim 1.—In a tool of the character described, in combination, a body or main portion, active members carried thereby and adapted to move in outwardly directions, a handling device pivotally connected to the body, whereby the tool may be set in line with the handling device for admission to a group of tubes through a straight-away passage be-



tween adjacent rows of tubes with the axis of the connection parallel with the tubes, and then turned at an angle to the handling device on said axis, whose position remains unchanged longitudinally to the tubes, to set the tool in operative position among the group of tubes, and means for moving the active members against the tubes to force them apart. Fifteen claims.

903,664. FLUE CLEANER. JAMES WM. BROWN, OF WINNSBORO, TEX.

Claim 1.—A flue cleaner comprising a cylindrical body provided with transversely-arranged openings, and flue-engaging members constructed of wire passed through the said openings and wrapped around portions

of the body to form exteriorly-arranged curved scraping portions, the scraping portion of each member being extended partially around and supported by the periphery of the body. Three claims.

904,429. FLUE SCRAPER. AUGUST B. HEIMANN, OF COALINGA, CAL.

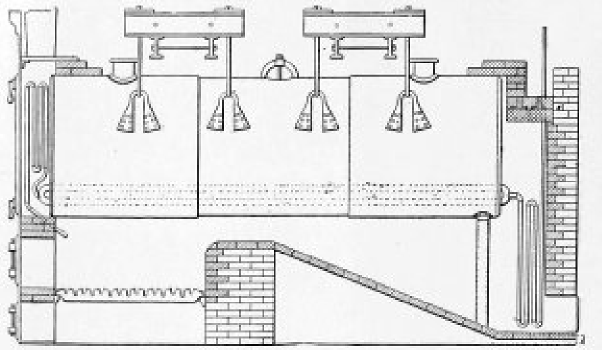
Claim 1.—A flue cleaner comprising a series of supporting bars provided with slots, a series of scraper plates having yoke-shaped scrapers mounted to slide in the slots in the supporting bars, and a frame connected to the supporting bars and provided with a detachable handle for reciprocating the scrapers simultaneously. Two claims.

904,494. ARCH FOR LOCOMOTIVE FURNACES. CHARLES BREARLEY MOORE, OF EVANSTON, ILL.

Claim 1.—A locomotive boiler fire-box or furnace, in combination with a group of arch tubes of less width than said furnace, a refractory arch laterally co-extensive with said group of arch tubes and resting thereon, and wedge-shaped bricks closing the spaces between the edges of said arch and respective sides of the furnace. Thirty claims.

904,051. BOILER FURNACE. OLIVER B. DAWSON, OF CALDWELL, N. J.

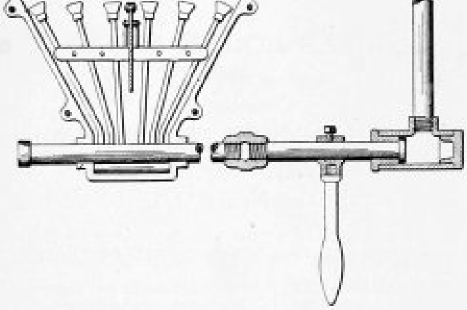
Claim.—The combination with a steam boiler furnace having a fire-box, an up-take at the rear end, boiler tubes open at their rear ends to said up-take, and a smokestack at the front of the furnace, of means for introducing highly-heated atmospheric air to said fire-box comprising a pipe open at one end to the atmosphere and extending into said up-take and coiled therein and communicating with one or more of said boiler tubes at their rear ends, and a second pipe leading from such boiler tubes at their front ends to said fire-box, said second pipe being coiled



and located beneath said smokestack and having its discharge end opening into the fire-box at or near the fire-bed, said pipes and coils being so located as not to be exposed within the fire-box to the direct action of the heat generated by the furnace. One claim.

903,971. BOILER-FLUE CLEANER. RICHARD W. HAMANN, OF ST. LOUIS, MO., ASSIGNOR TO EUGENE J. FEINER, OF ST. LOUIS.

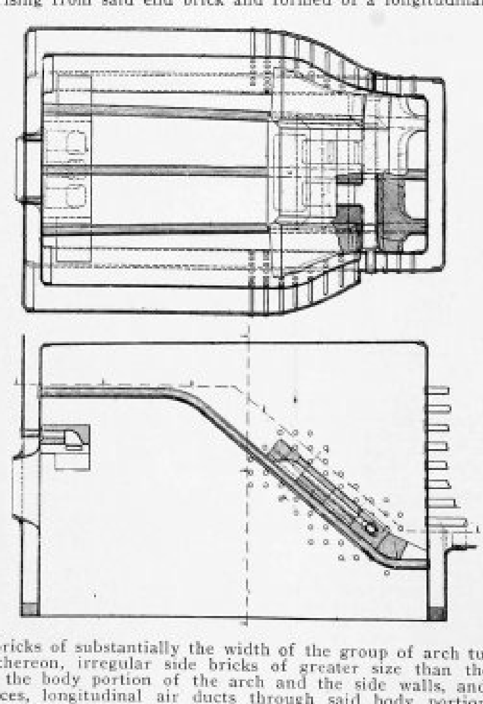
Claim 3.—The combination with a boiler, of a series of movable jet tubes arranged adjacent the boiler and projecting toward the boiler



flues, a movable protecting plate arranged immediately in front of the jet tubes, and means whereby the jet tubes and protecting plate are simultaneously actuated. Ten claims.

904,211. FRONT ARCH FOR NARROW LOCOMOTIVE FURNACES. CHARLES B. MOORE, OF EVANSTON, ILL.

Claim 5.—A locomotive boiler furnace having irregular side walls and provided with a group of longitudinal, inclined arch tubes, in combination with a refractory arch, comprising a bottom end brick of substantially the width of the furnace and abutting the flue sheet, a body portion rising from said end brick and formed of a longitudinal row of



similar bricks of substantially the width of the group of arch tubes, and resting thereon, irregular side bricks of greater size than the spaces between the body portion of the arch and the side walls, and closing said spaces, longitudinal air ducts through said body portion and a transverse air duct in the lowermost brick of said body portion, said transverse air duct communicating with the air through the sides of the furnace. Twelve claims.

THE BOILER MAKER

FEBRUARY, 1909

LAY OUT OF A HORIZONTAL RETURN TUBULAR BOILER 18 FEET LONG BY 72 INCHES DIAMETER.

BY R. R. STURGEON.

The object of the writer is to show by the sketches how a boiler of the type mentioned in the appended specifications would be laid out in the shop. It should be noted, however, that in certain localities quite a few changes would have to be made in the layout in order to pass inspection. The writer has found this particularly to be the case when boilers are designed by engineering firms. Very frequently, when the boiler is to be insured, the insurance company furnishes specifications, and, of course, in all cases the manufacturer has to build the boiler to pass the law's requirements. It is not my intention to design, but to show how the layout would look by following the specifications and order of construction.

In many shops, part of the layer-out's work is to order the material, so we will give a list of what is needed to lay out the work.

MATERIAL.

Two plates, .47 inch by 72⅝ inches by 228 inches, for front and rear courses.

One plate, .47 inch by 71¾ inches by 225 inches, for middle course.

One plate, .47 inch by 45 inches by 121 inches, dome plate.

Two plates, ⅜ inch by 15¾ inches by 68 inches, inside covering straps for front and rear courses.

One plate, ⅜ inch by 15¾ inches by 72 inches, inside covering strap for middle course.

Two plates, ⅜ inch by 10¼ inches by 72 inches, outside covering straps for front and rear courses.

One plate, ⅜ inch by 10¼ inches by 68 inches, outside covering strap for middle course.

Two flanged heads, 72 inches outside diameter by ⅝ inch thick, 2 inches internal radius on turn of flange, 3¼ inches straight flange. One of these heads to have two manholes 11 inches by 15 inches flanged inwards from face to head; same to be provided with patent pressed steel manheads, bolt, yoke and gasket. Center of upper manhole to be 20½ inches from center of head, and the lower manhole to be 27 inches from center of head to center of manhole.

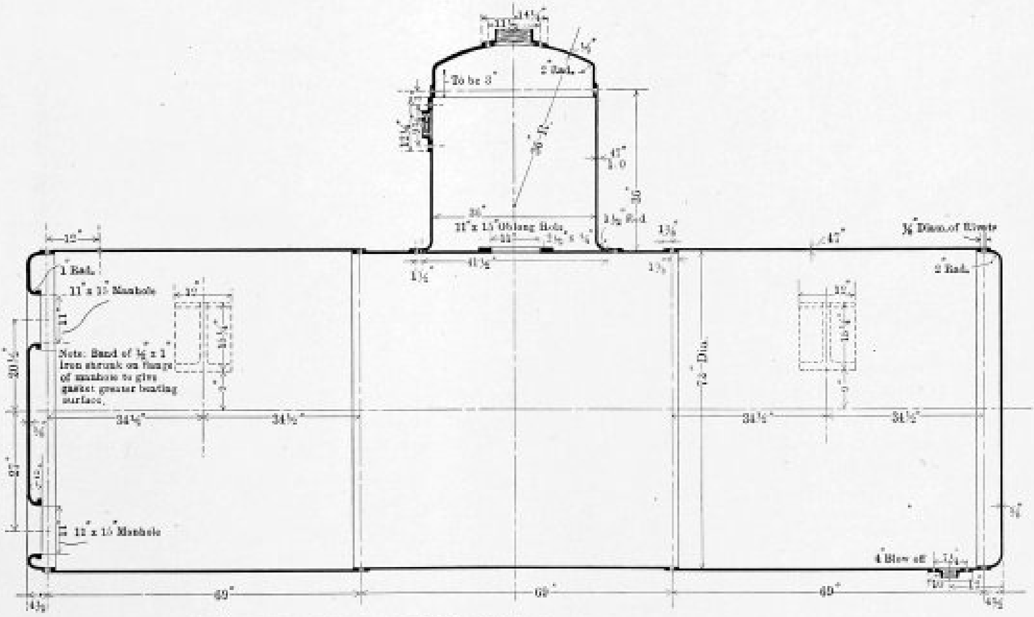


FIG. 1.—SHELL, HEADS AND DOME ASSEMBLED, SHOWING PRINCIPAL DIMENSIONS.

One flanged and dished head, 36 inches outside diameter by ½ inch thick, to be dished to a radius of 36 inches; 2 inches internal radius on turn of flange and 3 inches of straight flange.

The quality of steel to be homogeneous flange steel, and a certificate of test to be furnished. Steel to meet the requirements of any reliable insurance company. All other material needed to complete the boiler is, of course, added to this; such as flanges for pipe connections, brackets, etc., after the list is handed in to whoever might have charge of that part of the work in the office.

On receiving the material, we will proceed to lay out the boiler. Fig. 1 shows the heads, shell and dome of the boiler assembled, giving all the necessary dimensions. This, with the specifications, is all the layer-out gets with his order; in fact, it is all that is necessary. Figs. 2 and 3 show both heads laid out, and give correct figures showing the distance the braces will come on the shell of the boiler from the top and bottom center line. Fig. 2 also shows the location of the holes for the feed pipe and water column.

It is always necessary in laying out the boiler to find the exact circumference of the head, as it will be found in nearly every case that the head runs small or large. In this case it will be seen that the heads are a fraction over 72 inches in diameter, for by measuring around we find the circumference to be 226¼ inches. The writer finds the wheel to be the most convenient tool to measure a circle, as in measuring a head it can be done much quicker and without any assistance. However, some layer-outs prefer a steel tape line, and one is used about as much as the other.

Having the heads laid out, we next take up the rear course. The layout for this is shown in Fig. 4, which shows the necessary allowance in the length of the plate, which is called the take-up in rolling. This sketch also shows the location of the braces, with measurements corresponding with same taken from the rear head, Fig. 3. It should also be noted that there is an allowance made in these measurements. Very little attention is paid to this allowance by most layer-outs, and it hardly amounts to anything. However, it is correct.

The correct location of the brackets is also shown in this sketch. The centers for the rivet holes are not given, for the reason that nearly always these castings come from the foundry with the holes cored, and it is better to make a template for each casting in order to get fair holes. The layout for the blow-off connection is also shown. These dimensions can nearly always be secured by referring to the catalogue of the manufacturer from whom they are ordered, in case they are not at hand when you are ready for them.

Fig. 5 gives the layout of the first course. This is the same as Fig. 4, or the rear course, and can be marked off from it, leaving out all the brace holes and the 4-inch pipe hole. The holes for the braces in this plate can very quickly be put in by the layer-out after the plate is marked off.

Fig. 6 gives the layout for the middle course, or small course, of the boiler. It shows the correct total length of the plate so as to make a good fit. It will be noticed that in this layout there is ⅛ inch allowed on each end of the plates. This is to be taken off with the planer, and makes a perfect butt joint when the plates are rolled.

In Fig. 6 we also show the location of the opening for the dome, the two long braces from each head and the holes for the braces from the shell of the boiler to the shell of the dome. In the layout for the middle course it will be seen that the proper amount of lap is given, as it is not necessary to bevel this plate, while on each end course an allowance is made for the planer or bevel shear.

Fig. 7 gives a detail of the dome connection on a larger scale, showing the development of the hole in the plate and the layout of rivet holes.

Fig. 8 shows the development of the dome plate, location of holes for braces and the layout for the safety-valve connection. It will be seen that this plate is marked to be laid out on the opposite side from the stamp. This is done so as to have the center for the flange line on the inside when the plate is rolled, and saves the trouble of back-marking the flange line for the flange turner. It will also be noticed that an allowance is made on the outside lap for the stretch of material in flanging. If this allowance is not made, it would be found that there would be quite a large opening at the toe of the flange when the dome was finished.

Figs. 9 and 10 show the butt straps layed out for the end courses. Dotted lines on the inside strap show how the plates are to be scarfed. The marks *G*, *B*, *R* and *W* are to show where braces will come on the straps. Figs. 11 and 12 show the butt straps for the middle course, while Fig. 13 shows details of the braces required for the boiler.

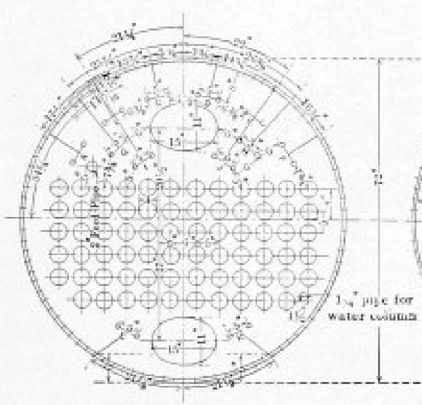


FIG. 2.

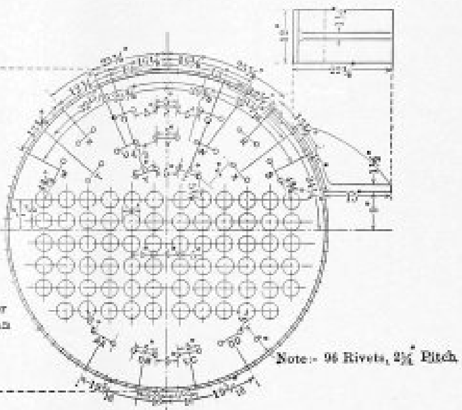


FIG. 3.

SPECIFICATIONS.

Dimensions.—To be 72 inches in diameter by 18 feet 0 inches long from face to face of heads.

Steel.—Boiler to be constructed of the best open-hearth homogeneous flange steel plates, same to meet the requirements of any reliable insurance company.

Shell and dome plates to be .47 inch thick.

Heads to be ⅝ inch thick.

Dome head to be ½ inch thick, dished to a radius of 36 inches.

Tubes.—To contain seventy best American lap-welded tubes of standard gage, 4 inches in diameter and 18 feet ½ inch long.

Dome.—To be 36 inches in diameter and 42 inches high. Shell of dome to be braced to shell of boiler with six crow-foot braces. Pad of braces to be ¾ inch by 2½ inches; flat bar iron. Rod of braces to be 1⅜ inches diameter; round iron. Braces to be about 24 inches long.

Riveting.—Boiler to be riveted throughout with steel rivets ⅞ inch diameter. Girth seams to be lapped and single riveted, with pitch of about 2¼ inches. Longitudinal seams to be triple-riveted butt joint, with double covering straps, having a rivet pitch of 3⅝ inches by 7¼ inches.

Head of dome to be single riveted to shell of dome. Pitch of rivets, 2¼ inches. Straight or vertical seams of shell of dome to be double riveted with rivet pitch of 3⅜ inches. Flange of dome to be double riveted to shell of boiler. Pitch of rivets, 3⅜ inches.

Openings.—Main steam opening on top of dome to be for 7-inch pipe. Safety valve opening on shell of dome towards front end of boiler to be for 5-inch pipe. Blow-off opening in bottom to be for 4-inch pipe. Opening in front head above tubes for feed pipe to be for 2-inch pipe. One opening to be provided in top of boiler near front end and another in a convenient low section for 1¼-inch pipe. Pressed steel flanges to be used.

placed ten above and two below the tubes on front head, and fourteen above and four below the tubes on back head; also six inside the dome running from shell of boiler. Shortest brace in boiler to be not less than 42 inches in length. Braces in dome can be about 24 inches long.

The shell of the boiler will be made in three equal rings, of

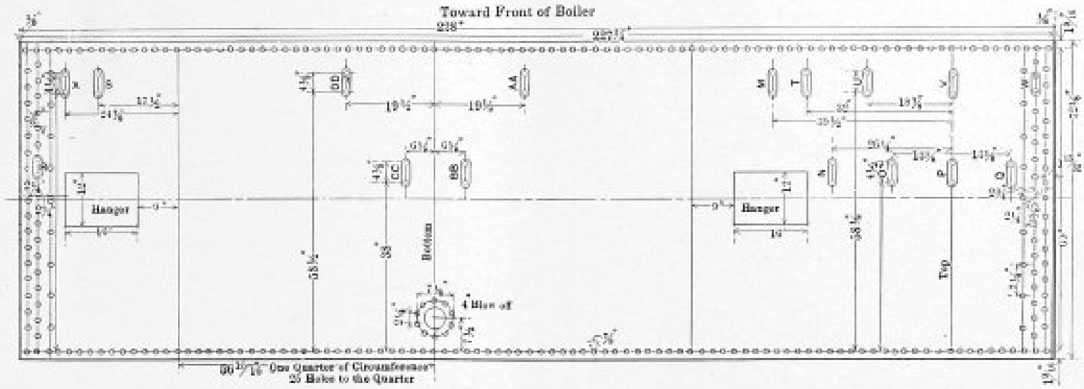


FIG. 4.—LAYOUT OF REAR COURSE.

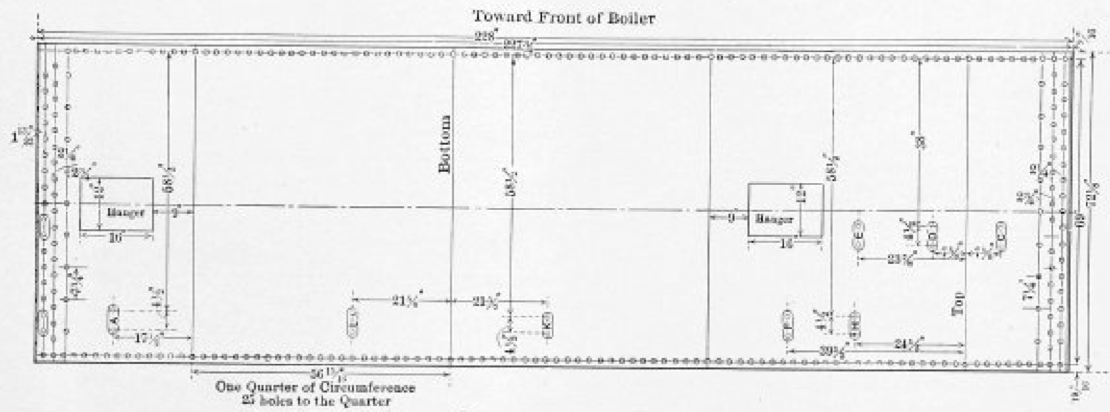


FIG. 5.—LAYOUT OF FRONT COURSE.

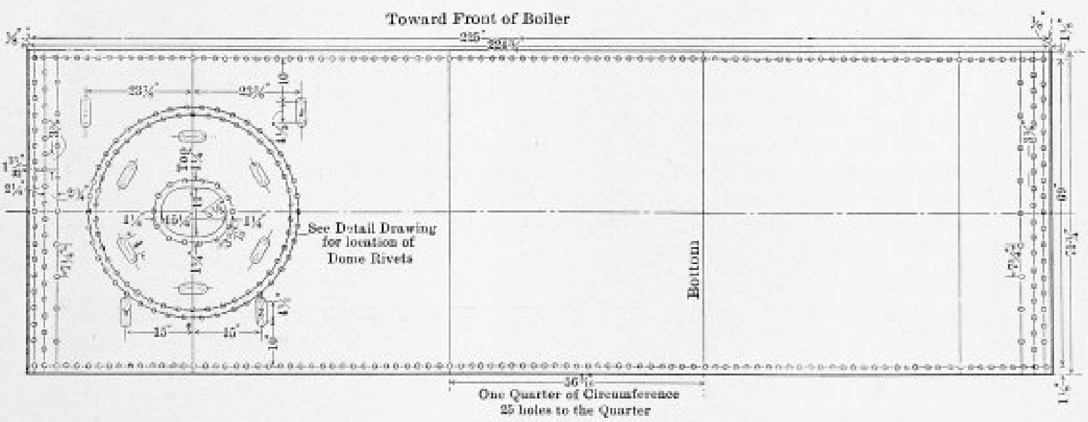


FIG. 6.—LAYOUT OF MIDDLE COURSE.

Pressure.—Boiler to be constructed for a working pressure of 125 pounds per square inch, and to be tested to a hydrostatic pressure of 188 pounds per square inch.

Feed Pipe.—Feed pipe to be 2 inches in diameter and about 12 inches long, perforated.

Lugs.—To have four lugs or brackets, two on each side.

Manholes.—To have two improved-type manholes, 11 inches by 15 inches, located one above the tubes and one below the tubes in front head.

Braces.—Heads to be stayed with thirty crow-foot braces, one plate to the ring, with longitudinal seams coming well above the fire line, and to break joints in the usual manner.

Heads to be flanged to an internal radius of not less than two inches.

Construction.—Tubes will be set in vertical and horizontal rows, carefully expanded in place with a straight roller expander. No self-feed or taper-roller expander to be used. If necessary, to cut tubes to proper length, same must be done in a neat and workmanlike manner; each end of tubes to be neatly turned over. Holes for tubes in heads to be drilled and chamfered. All rivets must be of the best quality open-hearth steel, with tensile strength of not less than 50,000 nor more than 62,000 pounds per square inch, elongation of 30 percent in 8 inches, and elastic limit equal to at least one-half the ultimate tensile strength. Heads of rivets must be of equal strength with the shanks. All rivet holes to be punched 1/16 of an inch smaller than required, shell plates to be rolled to a perfect circle, the work assembled and rivet holes reamed to full size. Rivet holes, when ready for riveting, to be 1/16 of an inch larger in diameter than the diameter of the rivet to be used.

All rivets, whenever possible, to be driven with strictly modern hydraulic riveters, allowing the rivets to cool and

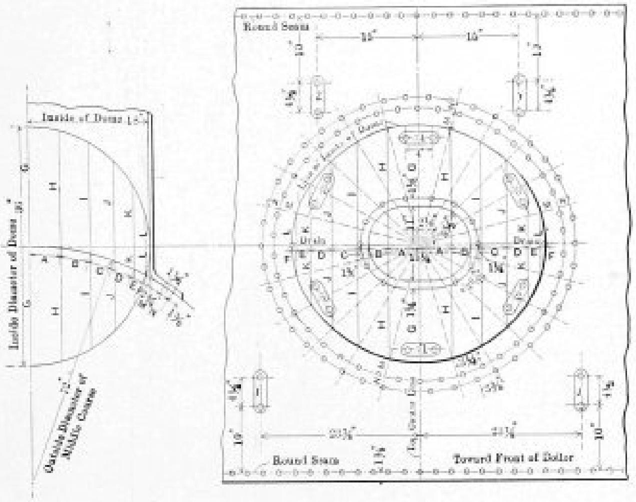


FIG. 7.—DOME CONNECTION.

shrink under standard pressure adopted by the American Boiler Makers' Association.

Braces to be so set and spaced as to bear uniform tension. The working strain on the braces not to exceed 7,500 pounds per square inch, making the usual allowance for the flat surface cared for by the surrounding shell, tubes and manholes. Where braces are placed below the tubes, they will be led well up on the shell of boiler to prevent obstructing the flow of sediment to the blowoff.

Lugs will be of cast iron, with a projection of about 15 inches from boiler, measuring 16 inches on boiler and 12 inches in width. Lugs to be 1½ inches thick and to be heavily ribbed and securely fastened to the boiler.

Feed pipe will be approximately 12 feet long, securely braced and located 3 inches above the upper row of tubes, entering through the front head. Feed pipe to be perforated

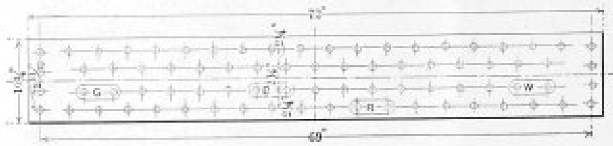


FIG. 9.—OUTSIDE STRAP FOR END COURSES.

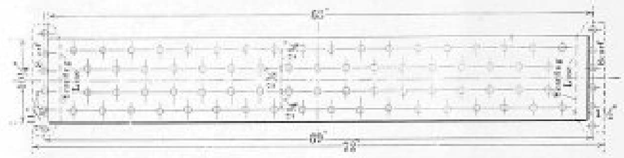


FIG. 10.—INSIDE STRAP FOR END COURSES.

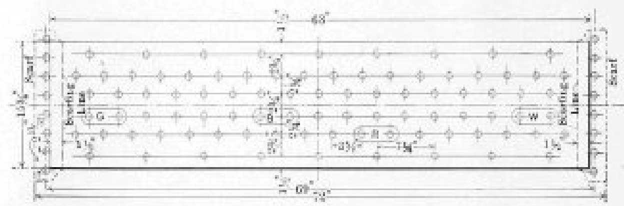


FIG. 11.—OUTSIDE STRAP FOR MIDDLE COURSE.

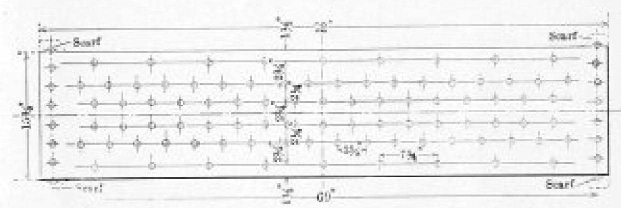


FIG. 12.—INSIDE STRAP FOR MIDDLE COURSE.

with 5/16-inch holes on each side, of sufficient number to equal the area of pipe. Inner end of pipe to be left open.

All tests of steel for tensile strength, elongation and reduction of area will be made at the place of manufacture. Shell will also stand customary bending tests without fracture, and in all respects will conform to the Association of American Steel Manufacturers' Standard Specification. Each plate to be plainly stamped with the name of maker, brand and tensile strength.

Plates to be properly beveled for calking and boiler thoroughly calked with round-nose calking tool. The above mentioned hydrostatic test to be applied and boiler to be tight at said pressure.

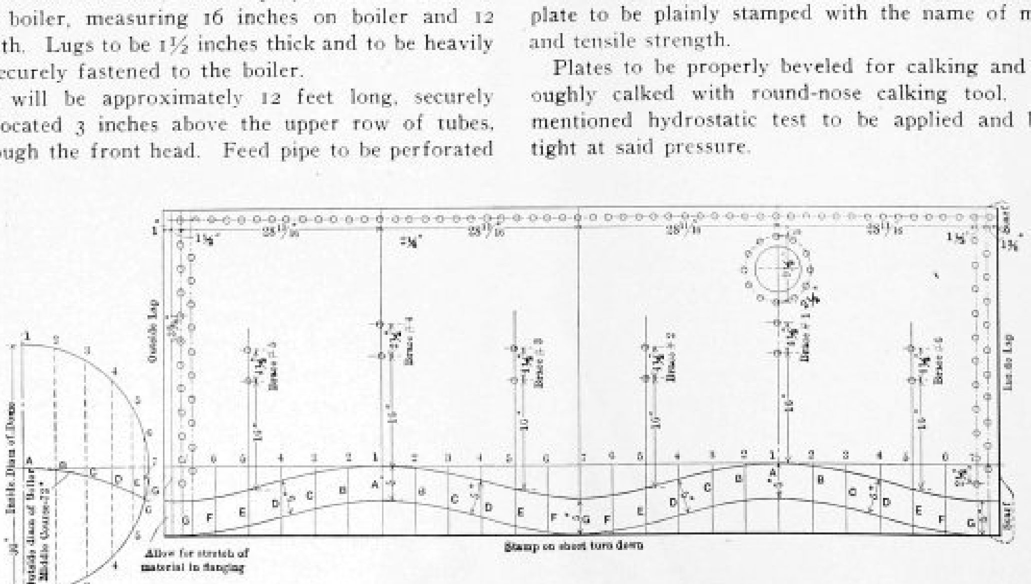


FIG. 8.—DEVELOPMENT OF DOME SHEET.

LOCOMOTIVE BOILER INSPECTION.*

The New York Legislature of 1905 added a provision to the railroad law, providing for the inspection of locomotive boilers, the appointment of boiler inspectors by railroad companies, the filing of certificates of inspection with the Board of Railroad Commissioners, and providing for the appointment of a State boiler inspector. The duty of enforcing this act devolves upon the Public Service Commission for the Second District as the successor to the Board of Railroad Commissioners.

Our last annual report outlined the duties of the commission under this law, but the subject is believed to be of sufficient importance and interest to justify a recapitulation of the principal provisions of the act, and a description of the preliminary work done under it.

The present law makes it the duty of every railroad corporation operating locomotive boilers in this State:

1. To provide for an inspection of locomotive boilers and appurtenances thereof at least every three months, by an inspector of suitable qualifications and attainments to perform the service required, and able to form a definite opinion regarding the safety and proper maintenance of locomotive boilers.

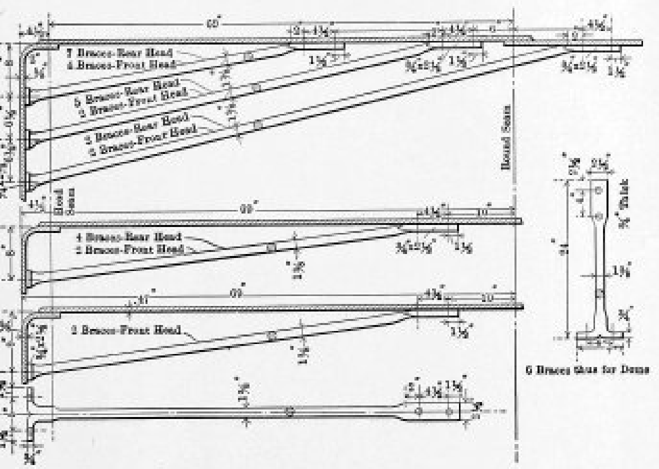


FIG. 13.—METHOD OF BRACING.

2. To provide necessary safety appliances on all locomotive boilers, and maintain these appliances in good working condition at all times.

3. To require all locomotive boiler inspectors to fill out and sign, under oath, a certificate covering each inspection made on each locomotive boiler, and to file one copy of said certificate with the chief operating officer of the railroad company, and one copy with the commission.

4. To require all locomotive boilers to be washed out at least once in every thirty days.

The law requires the commission to formulate rules and regulations for the inspection and testing of boilers in accordance with the above requirements, and gives the commission the right to require the removal of incompetent railroad inspectors. Under the above provisions of the law, the former Board of Railroad Commissioners, after a civil service examination, appointed Mr. G. P. Robinson as State boiler inspector; and as he has been found competent, Mr. Robinson has been retained by this commission.

Regulations for the care and inspection of locomotive boilers in conformity with the law were prepared by this commission shortly after it took office, and these regulations were made effective by order Sept. 1, 1907. The regulations were prepared after extended conferences with railroad mechanical officers, and were approved by representatives of the brotherhoods of locomotive engineers and firemen. Much effort was made in the preparation of these regulations to incorporate the best railroad practice, and to provide methods of enforcing the law which would be effective and at the same time capable of a reasonable and business-like execution. The operation of the regulations during the past year has been satisfactory, and no serious criticisms regarding them have been received from any source, although the fullest criticism has been invited, and the inspectors of the commission have been instructed to report all defects which may be found in the regulations, or any unnecessary hardship which may be shown in their enforcement. The commission is therefore justified in believing that the present regulations will require little if any change during the coming year.

There are about 6,000 locomotive boilers used constantly in this State, and about 1,500 more which are used occasionally, and which also require to be maintained and inspected in accordance with the State regulations. As there are about 54,000 locomotive boilers in use in the United States, the 7,500 supervised by this commission is about one-seventh of the total.

The boiler inspection regulations now in force contemplate two forms of report: First, a specification card, which gives a description of the general design of the boiler, the principal dimensions, thickness of sheets, measurement of seams, and the results of the calculations of the strains to which the principal parts are subjected, and from which the proper working pressure and the factor of safety can be computed. The age of the boiler, the tests to which the material was originally subjected, and any other data which may aid in determining the safe working pressure, are also required. This specification card is signed by the mechanical engineer of the railroad company or by another expert qualified to pass upon questions of boiler design and strength. The signature of the principal mechanical officer of the railroad company is also required.

The preparation of these specification cards has necessitated a large amount of work by the railroad companies, much of which has been caused by the large number of old boilers in use in the State, and for which no accurate records or drawings exist.

The railroads were given until Jan. 1, 1909, to file these specification cards, and where good reason could be shown a short extension of time has been granted. On Jan. 1, 1909 6,114 specification cards had been filed with this commission.

The principal calculations given on the specification cards for each boiler have been checked under the direction of the State boiler inspector, by a mechanical engineer who is familiar with locomotive boiler construction. The importance of this checking is indicated from the fact that serious errors have been found in over 800 cards filed by twenty-six out of eighty-three companies reporting, and these cards have been returned for correction. Unimportant errors in large numbers have been corrected by this department.

The specification cards of the boilers inspected in this State are being divided, for the purpose of examination, into groups, as follows: (1) Boilers less than twenty-five years old, of good, general and detail design, factor of safety more than 4, braces strained to less than 10,000 pounds per square inch, with longitudinal seams butt-joint, or otherwise, suitably reinforced; (2) boilers twenty-five years old or over; (3) boilers twenty years old or over, with factor of safety of less than 4½; (4) boilers fifteen years old or over, factor of safety under 4½, and having plain lap longitudinal seams; (5) boilers with factor of safety under 4; (6) boilers having calculated stresses in the braces of more than 10,000 pounds; (7) boilers

* From the second annual report of the New York Public Service Commission, Second District.

in which the general design or the design of details, as indicated by the specification cards, raise any question as to safety, although the calculated stresses and factors of safety may be within the limits given in the preceding groups.

The specification cards for boilers in the first group are passed without further examination. The cards for boilers in the remaining six groups are being examined with sufficient care to enable the experts of the commission to determine whether any represented require special examination, with a view of determining whether they are to be condemned, require to have weak points reinforced, or require to have the pressure reduced.

The following shows the number of boilers in each group, as determined by examination of the 6,114 boilers whose specification cards have been checked to date:

Number of boilers which do not meet the requirements of the first class	1,601
Number of boilers 25 years old or over	161
Number of boilers over 30 years old	14
Number of boilers of unknown age	19
Number of boilers 20 to 25 years old with factor of safety under 4½	144
Number of boilers 15 to 20 years old, having plain lap longitudinal seams and factor of safety under 4½	156
Boilers with factor of safety under 4	963
Boilers with braces having stresses exceeding 10,000 pounds per square inch	1,038

The specification cards thus far examined show factors of safety varying from 2.18 to 8.88. The boiler having the factor of safety of 2.18 has been condemned.

It is very evident from the results of the calculations thus far made that a rule requiring all boilers to meet an arbitrary factor of safety would be unjust in its application. To insist, for instance, upon a minimum factor of safety of 4½, which is considered by many railroad companies to be good practice, would require a reduction of pressure on many boilers of recent design, of the highest grade of construction and of unquestioned safety. It is therefore very evident that in determining the safety of a boiler it is necessary to take into account the general design, the design of the principal details, the age and the attention given to maintenance, before a reliable idea can be formed as to the pressure which can be safely permitted.

A certificate of inspection is required by law to be filed with the commission for each boiler in the State once in three months. One copy of this inspection certificate is posted in the locomotive cab, and one copy is filed with the chief mechanical officer of the railroad company. All certificates are checked upon receipt in the office of this commission, and compared with the certificates previously filed. The number of certificates filed for the year ended Dec. 31, 1908, was 29,421. Special filing cases are provided for the inspection certificates and specification cards, so that in case of accident to any boiler used in this State, all of the data reported to the commission can be used in the investigation.

If errors in the inspection certificates are found, letters are at once written or personal visits made by the State boiler inspector or an assistant. Several hundred certificates have been returned for correction. A record is kept of all errors made by the railroad inspectors as far as discovered, and if the record indicates carelessness or incompetency, the case is reported to the proper railroad officer. It has been found necessary to ask the companies to relieve twenty-five inspectors from this class of work on account of careless work and incompetency, although every effort has been made by the State boiler inspector to allow for the friction and lack of understanding incidental to the inauguration of a new system. Many cases have been found where the officers in charge of boilers, especially in the smaller companies, are not satisfactorily trained for this work. A great deal of extra labor has thereby been added in supervision, as in most cases these men do not understand technical letters, and personal calls have been necessary.

The companies reporting boiler inspections to this commission include twenty-two manufacturing companies owning locomotives which are used occasionally on railroad companies' tracks. While the law does not specifically cover these companies, it has seemed fair to the commission to compel such companies to comply with the boiler inspection requirements, or to require the railroad companies to refuse such companies the right to use such locomotives on the railroad companies' tracks in this State.

Forty-four of the companies out of eighty-three reporting have no facilities for repairing locomotives. These are mostly small railroad and manufacturing companies who cannot afford shops. A shelter is usually provided for the locomotives, and only the simplest hand tools are furnished. In the case even of some of the larger roads, the shop facilities are not adequate, and the men in charge of repairs and inspection have to work under serious disadvantages. Increased attention will be given by the equipment and boiler inspectors of this commission to such cases in the future, and companies will be asked to provide proper facilities for maintenance and inspection as rapidly as may appear to be reasonable in each case.

Considerable attention has been given by this department to the existing rules governing the size and capacity of safety valves required for the various designs and sizes of locomotive boilers, and it has been found that the rules now in force are unsatisfactory. The subject is, however, under consideration by the Master Mechanics' Association, by one or more of the prominent locomotive builders, and by manufacturers of safety valves, and it is probable that the matter will soon be put upon a more satisfactory basis.

Especial attention has been given to stay-bolt inspection, as broken stay-bolts constitute one of the most serious sources of danger in the operation of locomotive boilers; and the fact that there has been no explosion of a locomotive boiler in this State during the past year on account of broken stay-bolts is believed to be due in some measure to the strict inspection system required by the law. The regulations of the commission require that all stay-bolts shall be provided with tell-tale holes, drilled in the outer ends of the bolts in such a way as to show by the escape of steam when the bolt is broken. The only exception to this requirement is made in the case of such railroads as are able to prove to the commission satisfactorily that unusual care is devoted to the inspection and maintenance of locomotive boilers, and especially to stay-bolt inspection. The railroad companies' records show that a much larger number of stay-bolts are being removed at monthly inspections than has been customary in the past, and although this involves additional labor and expense in maintenance, the work is believed to be abundantly justified by the increased safety secured.

It is a frequent practice of small companies to purchase second-hand locomotives. In such cases, the complete requirements of the commission, as to inspection and testing, have been insisted upon; special examinations have been made where no satisfactory records exist, and in some cases the boilers of such locomotives have been condemned, and in other cases reduction in pressure has been ordered.

An investigation has been made of every serious accident which has been reported during the year to a locomotive boiler in this State.

The following is a summary of the accidents investigated:

Number of Accidents.	Cause of Accident.	Number of Persons Killed.	Number of Persons Injured.
1	Pocket flue blowing out	....	1
1	Arch tube burst	....	1
4	Plugs blown out, nuts stripped and studs blown out	....	4
1	Burst flue	....	1
1	Flue pulled out	1	1
11	Low water	8	14

The reports of these accidents are on file in the office of the commission. Six additional slight accidents have not been investigated. The ratio of accidents to locomotives in service is 1 to 299; ratio of persons killed to locomotives in service, 1 to 829; ratio of persons injured to locomotives in service, 1 to 266.

Number killed during 1907	6
Number injured during 1907	31
Total number killed and injured	37
Number killed during 1908	9
Number injured during 1908	28
Total number killed and injured	37

It will be noted that the principal cause of boiler accidents is low water. In most cases such accidents are principally the fault of the engineer operating the locomotive, and he frequently has to pay the penalty for his neglect by loss of life. The only way in which this commission can exercise its influence in the prevention of accidents of this character appears to be in the following directions: (1) By requiring the best of care in the maintenance of gage cocks and water glasses; a great deal of attention has been given to this subject by the inspectors of the commission, and in every accident investigation involving low water, a careful inquiry is made as to the condition of these parts; (2) by requiring the location of gage cocks and water glasses, in reference to the crown sheet, to be carefully determined; the filling out of the specification cards requires, in doubtful cases, that measurements of the height of the crown sheet be taken, and a number of cases have been found where gage cocks and water glasses were wrongly located; (3) by requiring special attention of railroad companies to the design and the maintenance of injector and feedwater appliances; in every case of low water the condition of the injectors and feed apparatus has been the subject of careful inquiry, and the necessity of giving special attention to these portions of the locomotive equipment has been the subject of consultation with railroad mechanical officers.

In this department of its work the commission has received, for the most part, the cordial co-operation of railroad officers, the great majority of whom appreciate keenly the necessity of strict maintenance and inspection of locomotive boilers, and accept cordially any suggestions which may be offered to secure increased safety. The value of this part of the commission's work has, we believe, been especially manifest in the case of small railroads which do not maintain a complete mechanical staff. Out of eighty-three companies reporting locomotive boiler inspections to this commission, forty-seven do not maintain any mechanical organization, and are, therefore, for the most part, without any expert advice in reference to this subject.

While radical defects have been found in many locomotive boilers, and in the methods of inspection and maintenance on some of the large railroads as well as on the smaller ones, the general result of the inspection work justifies the statement that the railroads in this State are giving careful attention to this subject, and the remarks in last year's report may properly be repeated, as follows:

"It is but fair to say that the commission has found it unnecessary to make any suggestions to some of the railroads in regard to the care of locomotive boilers, as the rules and methods of inspection now carried out on these railroads are more exacting than the commission feels warranted in enforcing upon all railroads."

The inspection on other roads, however, has demonstrated the importance of this branch of the commission's work, and has, we believe, resulted in substantially raising the standard of locomotive boiler inspection throughout the State by extending the application of the best practice in maintenance and inspection to all companies.

REINFORCED OPENINGS IN BOILER SHELLS.

BY S. F. JETER.

Although calculating the proper reinforcement required to restore the original strength to the shell of a boiler or other cylindrical vessel, after having cut an opening such as required for a manhole, is apparently simple, there is probably no other feature of boiler construction about which so little real information exists. Most of the books dealing with the structural details of boilers either skip it entirely or state in a general way that the reinforcing plate should be of equal strength to

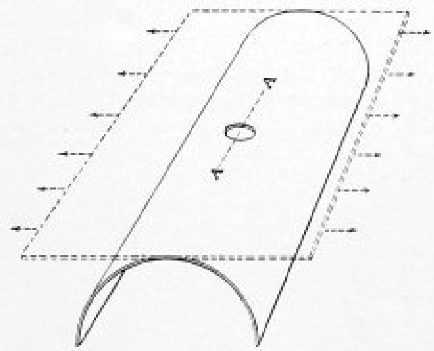


FIG. 1

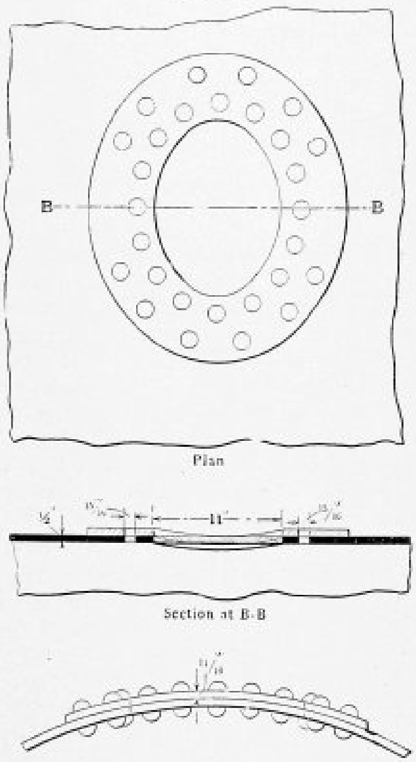


FIG. 2

the metal removed from the shell in cutting the opening. One of the more recent works on boilers says: "The determination of stresses in a manhole ring, even if approximate methods are used, is both difficult and uncertain." This expresses the situation exactly. In fact, there is so much difficulty in attempting to analyze the stresses that are present in this form of construction that there is no probability of any definite knowledge being obtained on the subject until tests on full-sized specimens are made to ascertain just what takes place. The purpose of this article is only to show how manhole reinforcements are generally calculated, give formulas for these calculations and to point out some features about such reinforcements.

Without any attempt at analysis of the stresses, it may be stated in a general way that when an opening of considerable size is cut in the shell of a boiler, and the opening closed by a cover which is not rigidly attached to the shell at the edge of the opening, the stresses introduced in the sheet in the vicinity of the opening, due to internal pressure, tend to deform the shell radially, as well as to produce direct tensile stresses, both circumferentially and lengthwise the shell, and to resist this deformation it is advisable that the reinforcing piece have some depth, so as to resist bending.

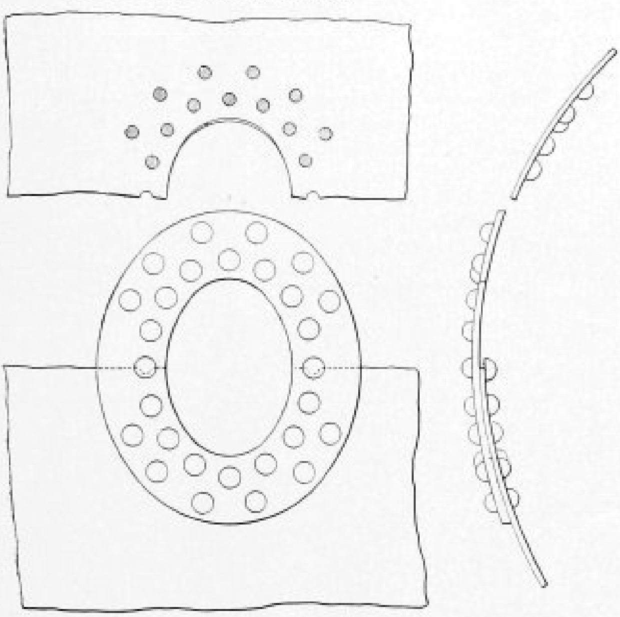


FIG. 3.

That such stresses as pointed out do actually exist is sometimes made evident in boilers equipped with domes, especially if the opening in the shell communicating with the dome has been cut the full size of the dome. In such cases there is some fairly well-defined limit of pressure, at which the boiler may be operated and remain tight; pressures beyond this limit causing distortion of the shell, which results in leaking at the seam where the dome flange is riveted to the shell.

The usual methods of calculating manhole reinforcements ignore the stresses just mentioned, and assume that they are the same as if the sheet were flattened out and being pulled apart in a direction at right angles to a plane through the center of the opening and axis of the boiler. Thus in Fig. 1 the solid lines represent the actual position of the sheet in the boiler, while the dotted lines with the arrows show how the stresses are assumed to come on the sheet for the purpose of making the calculations. In elliptical-shaped openings, as used for manholes, the shortest diameter is generally placed lengthwise of the boiler, as illustrated in Fig. 1, for this weakens the shell the least, on account of removing the minimum amount of metal at right angles to the direction of the principal stresses. The usual practice in designing reinforcements is to make them of such proportions that the strength of the metal in tension on a line passing through the center of the opening, parallel to the axis of the boiler, as *A A*, Fig. 1, is the same after the reinforcement has been applied as it was before the opening was cut in the shell, and the reinforcement is double-riveted to the shell. This latter requirement is to insure stiffness, rather than to add strength to resist shearing of the rivets, although it is, of course, necessary to see that the riveting is of sufficient strength to resist the shearing strains brought upon it.

Thus in Fig. 2 the area of metal shown cross-sectioned should be equal to that shown hatched, this latter being the cross-section of the metal removed from the shell. The small hatched portions on each side shown below the blank spaces in the reinforcement represent the metal removed by drilling the rivet holes, which must be added to the amount removed by cutting the opening. The rivets are arranged so that only one on each side need be considered, as is apparent from the plan. To calculate the dimensions of a ring which will have an equivalent section, as shown in Fig. 2, proceed as follows: The thickness of the shell would be known, and for present purposes it will be assumed as ½ inch. The diameter of the rivet holes would also be known, for they would be made the same as used in the seams to facilitate construction. Their diameter will be assumed as 15/16 of an inch. The thickness of the reinforcing ring should now be selected, and in the present case it will be taken as 11/16 inch. The only remaining dimension of the ring is its width, which can be obtained as follows, assuming that the ring and shell are of the same tensile strength per square inch:

The area of the metal removed from the shell is

$$11 \times \tfrac{1}{2} = 5.5$$

square inches for the manhole opening, plus

$$2 \times 15/16 \times \tfrac{1}{2} = 0.9375$$

square inch by the rivet holes on each side, or a total of 6.4375 square inches of metal to be replaced by the ring. Since the ring is assumed to be 11/16 inch in thickness, the width of section of solid metal would have to be such that the width times 11/16 would be equal to $\frac{6.4375}{2}$ square inches, the area of metal removed from the shell being divided by 2 on account of only one side of the ring being considered in the calculation, the width of section of metal in the ring would therefore be equal to

$$\frac{6.4375}{2} \div 11/16 = 4.68$$

inches. Now, since this represents the actual width of the section of metal required 15/16 must be added to it, to allow for the rivet hole, as shown in Fig. 2, making the actual width of reinforcement required 5.6175 inches, or 5⅝ inches.

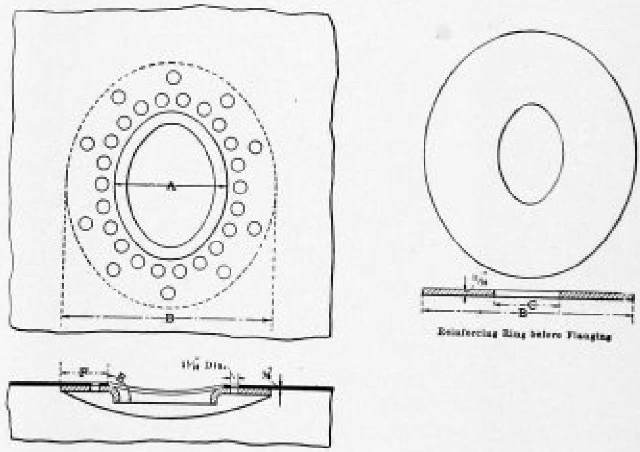


FIG. 4.

The next factor to be considered is the possibility of shearing the rivets which attach the reinforcing ring to the shell, and which would result in failure similar to that illustrated in Fig. 3. It is seen from the illustration that one-half of the rivets used in the reinforcement less one (which allows for the two rivets along the line of separation of the plate) must be sheared to cause failure in this manner, and as the strain is considered as being equally divided among the rivets, the rivet area should be properly proportioned to that of the section of the ring, using the tensile strength of the ring and the shearing strength of the rivets in arriving at the correct proportion. Thus, if the shearing strength of the rivets is assumed to be 42,000 pounds per square inch, and the tensile strength of the reinforcement 55,000 pounds per square inch, then there would be required

$$\frac{55{,}000}{42{,}000} = 1.31$$

square inches of rivet area for each square inch of area of the section of the reinforcing ring, or in the present case the area of rivets sheared as illustrated in Fig. 3 would have to be

$$1.31 \times 6.4375 = 8.43$$

square inches, or more; and since the area of a 15/16-inch rivet is 0.6903, there would be required

$$\frac{8.43}{0.6903} = 12.2,$$

or thirteen rivets in each half, or 26 + 2 = 28 rivets or more in the entire ring. The two additional rivets are to cover those on the center line of opening, as shown in Figs. 2 and 3. In laying out the rivets on the reinforcing ring it is the custom to place those on the inside row, suitable distances apart, to permit thorough calking for a tight joint, and then adding an outer row to make the connection double riveted. Often when two whole rows give an excess of rivet area required, every other rivet in the outer row is dropped, as illustrated on the reinforcement shown in Figs. 4 and 5.

Manhole reinforcements of the form shown in Fig. 2 have been placed on boilers and have given good service, but with high pressures there is a tendency toward distortion radially, which adds to the difficulty of keeping the joint tight, and on this account the form of reinforcement generally used on high-pressure work to-day is shown in Fig. 4, this form being known as the McNeil flanged manhole frame. It is flanged hot from plate of the same quality as the boiler shell. The flanged edge forming the manhole proper is faced, and in some instances the manhole cover used with this form of reinforcement contains a groove into which the packing is placed, the lip of the reinforcement fitting into the groove. When properly fitted this makes an excellent joint, as it is practically impossible to squeeze or blow the packing out.

To calculate the dimensions of such a reinforcement to replace the metal removed from the shell, it is, of course, necessary to know the dimension *A*, Fig. 4, which in this case is greater than the width of the manhole, the increase being generally from 3 to 3½ inches more than the manhole opening. It is also necessary to know the dimension *C*, or width of the opening in the reinforcing plate before flanging. To estimate this dimension on a reinforcement already flanged, the dimension *E* may be measured with a tape or by rolling a rule around on the surface and then adding this dimension to *F* to obtain the width of the flange. On account of the drawing down of the metal in the flanging process, it is safest to take dimension *E* about ½ inch less than it actually measures. After the above dimensions have been obtained, the calculation of the strength of the reinforcement is proceeded with in a manner similar to that for Fig. 2.

Assuming the thickness of the shell and the reinforcing plate and diameter of rivet holes, as shown in Fig. 4, the width of opening *C* as 8 inches and *A* 14 inches, the following would result in determining dimension *B*, or total width of the reinforcing plate and the number of rivets required:

The metal removed from the shell, in square inches, equals

$$(\tfrac{1}{2} \times A) + (2 \times 1\ 1/16 \times \tfrac{1}{2}) = 8.0625$$

square inches. Therefore, width *B* of the reinforcement must be such that

$$[B - (C + 2 \times 1\ 1/16)]\ 11/16 = 8.0625,$$

or since *C* equals 8 inches, $B = 21.78$ inches. The area of the rivets on each side of the reinforcement should equal

$$8.0625 \times \frac{55{,}000}{42{,}000} = 10.56$$

square inches, or since the area of a 1 1/16-inch rivet is 0.8866 square inch, the number on each side, exclusive of the ones on the center line, should be

$$\frac{10.56}{0.8866} = 11.92,$$

or twelve rivets. Therefore the layout, as shown on Fig. 4, would be all right as regards the rivet strength, since each side contains fifteen rivets.

While it is customary, as stated before, to have the reinforcing ring and rivets specified of equal strength to the metal

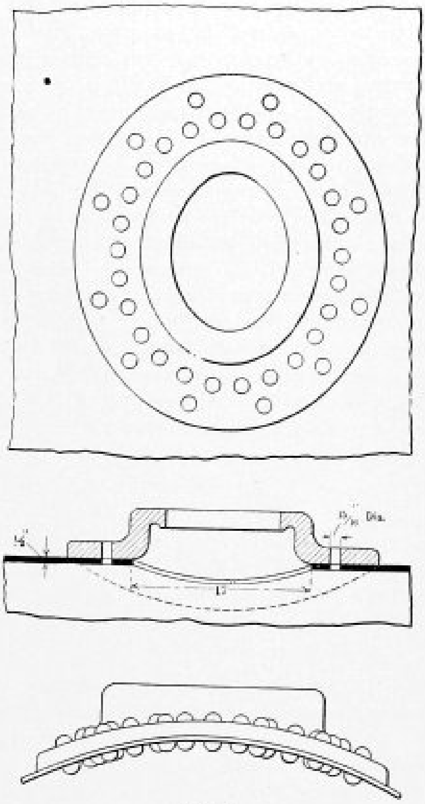


FIG. 5.

removed from the shell, it would doubtless be perfectly safe to design reinforcements for openings as small as manholes, so that the reinforcement would be of the same relative strength when compared with the metal removed, as is obtained in the longitudinal seams of the boiler, as compared with the solid plate. To calculate the reinforcement on this basis proceed as follows, using a reinforcement like that shown in Fig. 2 for the sake of simplicity:

Assuming that the boiler in question has a longitudinal joint of 72 percent efficiency, then the amount of metal required in the reinforcement would be 72 percent of that removed from the shell; and using the same dimensions for thickness of plate and ring and size of manhole opening and rivets, as given in Fig. 2, the calculation would result as follows: The metal removed from the shell is 6.4375 square inches, as before. The metal to be replaced by the ring equals

$$6.4375 \times 0.72 = 4.635$$

square inches. The width of the ring =

$$\frac{4.635}{2} \div 15/16 = 4.308$$

inches. The rivet area required in each half of the ring equals

$$\frac{55{,}000}{42{,}000} \times 4.635 = 6.07$$

square inches, or since the area of a 15/16-inch rivet is 0.6903 square inch there would be required

$$\frac{6.07}{0.6903} = 8.8,$$

or nine rivets in each half of the ring, exclusive of the two on the center line, or twenty rivets in all. A reinforcement equivalent to any joint efficiency may be calculated in a similar manner.

All of the reinforcements considered so far have been assumed to be of metal of equivalent strength to that of the shell. However, they are sometimes made of cast iron, and the calculations have to be modified accordingly.

Fig. 5 illustrates one form of cast-iron reinforcement which is placed on the outside of the shell. It is considered to be the best practice to locate all reinforcements on the inside of the shell, but the form shown in Fig. 5 has one advantage, and this is that in boilers where there is comparatively little room between the top of the shell and the tubes, entrance through the manhole is greatly facilitated when made of this form. This applies especially to boilers of small diameter.

To calculate the proper dimensions of a reinforcement of cast iron as illustrated in Fig. 5, the first step is to decide upon the relative strength of the reinforcing metal and the shell. Gray cast iron when used in boiler construction is generally credited with an ultimate tensile strength of 18,000 pounds per square inch, and assuming the strength of the shell to be 55,000 pounds per square inch, there would be required

$$\frac{55{,}000}{18{,}000} = 3.05$$

square inches of cast iron to be equal in strength to 1 square inch of the shell. Therefore, with a 17-inch opening and two 15/16-inch rivet holes in a ½-inch shell, as illustrated in Fig. 5, there would be removed 9.4375 square inches of metal, and to replace this it would require

$$9.4375 \times 3.05 = 28.78$$

square inches of cast iron, or the combined areas of the two sides of the reinforcement shown cross-sectioned in Fig. 5 should be equal to this amount. The rivets required are calculated in the same manner as was done for the other forms of reinforcement, based on the amount of metal removed from the shell. Thus,

$$9.4275 \times \frac{55{,}000}{42{,}000} = 12.35$$

square inches of rivet area on each half, exclusive of the two rivets on the center line, or

$$\frac{12.35}{0.69} = 17.9,$$

or eighteen rivets on each side in addition to the two on the center line, which would make thirty-eight 15/16-inch rivets required in all. If it had been desired to make the cast-iron reinforcement of equal strength to the longitudinal seam, then the metal removed from the shell should be first multiplied by the efficiency of the joint, and the result multiplied by the relative stength between the cast iron and steel plate, and also the same process used in obtaining the rivet strength required, or for an 85 percent joint the calculations would be as follows, using the dimensions shown in Fig. 5:

$$9.4375 \times 0.85 = 8.02$$

square inches of equivalent strength to that of the shell plates, which is to be replaced with cast iron, or the total net cross-sectional area of the reinforcing ring should be

$$8.02 \times 3.05 = 24.46$$

square inches, instead of 28.78 square inches, as before. The rivet strength required would be correspondingly reduced, or

$$8.02 \times \frac{55{,}000}{42{,}000} = 10.5$$

square inches of rivet area required in each half of the ring exclusive of the two rivets on the center line.

To condense the principles for calculating the reinforcements required for manholes, as set forth in this article, and make them readily available, it is best to state them in the form of formulas and the following notation is used for this purpose:

T = Tensile strength of shell in pounds per square inch.
T' = Tensile strength of reinforcing metal in pounds per square inch.
t = Thickness of shell in inches.
t' = Thickness of reinforcement in inches.
d = Diameter of rivet holes in reinforcement in inches.
S = Shearing strength of rivets in pounds per square inch.
D = Width lengthwise of the shell of the opening cut in the sheet.
W = Width of each side of the reinforcing ring in inches.
E = Efficiency of the reinforcement as compared with the solid sheet.
N = Total number of rivets required in the reinforcement.

From the following formulas the values of W, N or t' may be calculated when all the other factors are known. If it is desired to design a reinforcement of such proportions that it will be equivalent in strength to the metal removed from the shell, or of 100 percent efficiency, the factor E may be omitted, which produces the same results as if it were given a value of unity corresponding to 100 percent. When the material of the reinforcement and that of the shell are of the same tensile strength, the factors T and T' cancel out in formulas (1) and (3), and, therefore, in such cases they may be omitted.

$$W = \frac{t\,T\,E\,(D + 2d)}{2t'\,T'} + d. \qquad (1)$$

$$N = \frac{t\,T\,E\,(D + 2d)}{0.3927\,d^2\,S} + 2. \qquad (2)$$

$$t' = \frac{t\,T\,E\,(D + 2d)}{2T'\,(W - d)}. \qquad (3)$$

To obtain the efficiency of a manhole reinforcement already constructed, it is only necessary to substitute the correct values in the formulas (4) and (5), and use the one which gives the lowest value for the efficiency, as is done in calculating riveted joints. It should be noted, however, that in the case of reinforcements it is possible to have an efficiency of more than 100 percent. Formulas (4) and (5) are derived from (1) and (2) by transposition:

$$E = \frac{2t'\,T'\,(W - d)}{t\,T\,(D + 2d)}. \qquad (4)$$

$$E = \frac{0.3927\,d^2\,S\,(N - 2)}{t\,T\,(D + 2d)}. \qquad (5)$$

To make the use of these formulas clear the following examples are given: It is desired to place a manhole reinforcement similar to that shown in Fig. 2 on a manhole which is 12 by 16 inches in size, the short diameter to be located lengthwise of the shell. The stock available for this reinforcement is bar iron, of ¾ inch thickness and 45,000 pounds tensile strength. It is desired to know what width of bar must be selected to make the reinforcement of 82 percent efficiency. The rivets to be used are ¾ inch, driven in 13/16-inch holes, and they are assumed to have a shearing strength of 38,000 pounds per square inch. The shell of the boiler is of steel, 7/16 inch in thickness and of 52,000 pounds tensile strength per square inch. From this description it is noted that the various letters used in the formulas have the following values:

D = 12 inches.
d = 13/16 or 0.8125 inch.
E = 0.82.
T = 52,000 pounds.
t = 7/16, or 0.4375 inch.
T' = 45,000 pounds.
t' = ¾, or 0.75 inch.
S = 38,000 pounds.

It is desired to find the correct values of W and N, and by substituting the above values in formula (1) the following is the result:

$$W = \frac{0.4375 \times 52{,}000 \times 0.82\ (12 + 2 \times 0.8125)}{2 \times 0.75 \times 45{,}000} + 0.8125 = 4.58$$

inches. To determine the number of rivets that would be required in this reinforcement, substitute the values in formula (2) thus,

$$N = \frac{0.4375 \times 52{,}000 \times 0.82\ (12 + 2 \times 0.8125)}{0.3927 \times 0.8125 \times 0.8125 \times 38{,}000} + 2 = 27.8,$$

or twenty-eight rivets. It is, of course, necessary to have the number of rivets used divisible by 2, so they may be laid out symmetrically with respect to the center line lengthwise of the shell. In designing a flanged manhole reinforcement like Fig. 4, formula (3) will be found the most practical to use, for each manufacturer, to facilitate construction, adopts a fixed size of manhole to be used on the boilers which he builds, and this causes the dimensions B and C on the unflanged plate, Fig. 4, to become uniform, and therefore the width of flange, or W, is fixed. With the other factors known, formula (3) may be used to determine the different thicknesses of reinforcements required to accommodate the various shell thicknesses. For example, a 14-inch opening, for a 11 by 15-inch manhole, is cut in the shell of a boiler whose thickness is 9/16 inch and tensile strength 60,000 pounds per square inch, and the reinforcing plates required for this size manhole have been found to be 24 inches across lengthwise of the shell, with an opening 8 inches wide punched out of the center, leaving the dimension corresponding to W in the formulas 8 inches. Assuming that the material of this reinforcing plate is flange steel of 55,000 pounds tensile strength, and that it is to be riveted to the shell by 1-inch rivets driven in 1 1/16-inch holes, the shearing strength of the rivets being taken at 40,000 pounds per square inch, of what thickness should the reinforcing plate be, if its strength is to be equal to that of the metal removed from the shell? Substituting the above values in formula (3) would give the following results:

$$t' = \frac{0.5625 \times 60{,}000 \times 1\ (14 + 2 \times 1.0625)}{2 \times 55{,}000\ (8 - 1.0625)} = 0.713$$

inch, or the reinforcing plate would have to be 23/32 inch in thickness. The number of rivets required would be found from fromula (2) as before:

$$N = \frac{0.5625 \times 60{,}000 \times 1\ (14 + 2 \times 1.0625)}{0.3927 \times 1.0625 \times 1.0625 \times 40{,}000} + 2 = 32.7,$$

or thirty-four rivets required.

To illustrate the use of formulas (4) and (5), assume that a reinforcement similar to that shown in Fig. 2 was placed on a 11 by 15-inch manhole, the various dimensions and strengths being as follows: Thickness of shell ½ inch; tensile strength of shell, 50,000 pounds per square inch; thickness of reinforcement, 13/16 inch; tensile strength of reinforcement, 48,000 pounds per square inch; width of reinforcement, 5¼ inches; diameter of rivet holes, ⅞ inch; shearing strength of rivets, 38,000 pounds per square inch; number of rivets used in the reinforcement, twenty-eight. Substituting these values in formula (4), we get

$$E = \frac{2 \times 0.8125 \times 48{,}000\ (5.25 - 0.875)}{0.5 \times 50{,}000\ (11 + 2 \times 0.875)} = 1.069,$$

or 106.9 percent; that is, the reinforcing ring is 6.9 percent stronger than the metal removed from the shell.

As regards the strength of the riveting we have from formula (5)

$$E = \frac{0.3927 \times 0.875 \times 0.875 \times 38{,}000\ (28 - 2)}{0.5 \times 50{,}000\ (11 + 2 \times 0.875)} = 0.932,$$

or 93.2 percent; that is, the reinforcement as regards the shearing of rivets is 93.2 percent as strong as the metal removed from the shell in cutting the opening for the manhole reinforcement and the rivets.

In designing a reinforcement of the shape shown in Fig. 5, it is best first to make a sketch like Fig. 6 to obtain approximate values for dimensions a, b and c, and using the sum of these dimensions for a trial value for W in formula (3) and

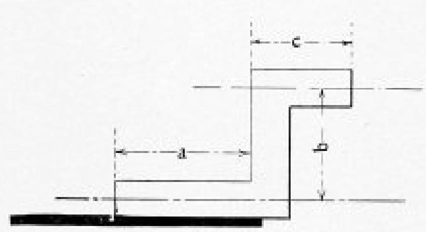


FIG. 6.

determine t', and from these values the area of reinforcing metal can be found, after which the dimensions of the reinforcement can be varied at will, the only requirement being to have the area of metal equal to or greater than the amount required.

It is, of course, understood that the formulas given in this article are all based on the assumption that the rivets are so arranged that only one rivet hole on each side of the manhole adds to the section of metal removed from the shell, and detracts from the section of metal in the reinforcing ring. To insure that this is the case and allow the two rows of rivets used to be placed reasonably near to each other, it will be found advisable to adopt a layout of rivets on each side of the center of the opening, lengthwise the shell, similar to that shown in Figs. 2, 3, 4 and 5. While the methods of calculating reinforcements as contained in this article are perfectly safe for openings the size of a manhole, it should be remembered that with a considerable increase in size of openings, numerous factors which have not been considered here would become of such importance as to seriously affect the results, and, as stated at the beginning, practically no definite information exists regarding the problem when these factors are taken into account.—*Power and the Engineer.*

FLANGING BOILER PLATES.—VIII.

BY JAMES CROMBIE.

Special Flanging and Bending.

There are many shops that are not equipped with a flange press, yet they turn out good machine flanged work by the aid of a portable riveter. A portable hydraulic riveter of the hinged, style can be used for many of the jobs that have already been mentioned in these articles, especially where material has been rolled or set up to a certain shape, and then requires a part to be flanged. Heating the part would change the shape already acquired, and it is thus necessary to turn the flange without heating the plate. The riveter can be fitted with a pair of flange blocks, as in Fig. 82. By traveling along the edge of the plate the flange can be formed cold. The machine will have to travel several times over the surface, as it will not turn each little part over and finish it at once.

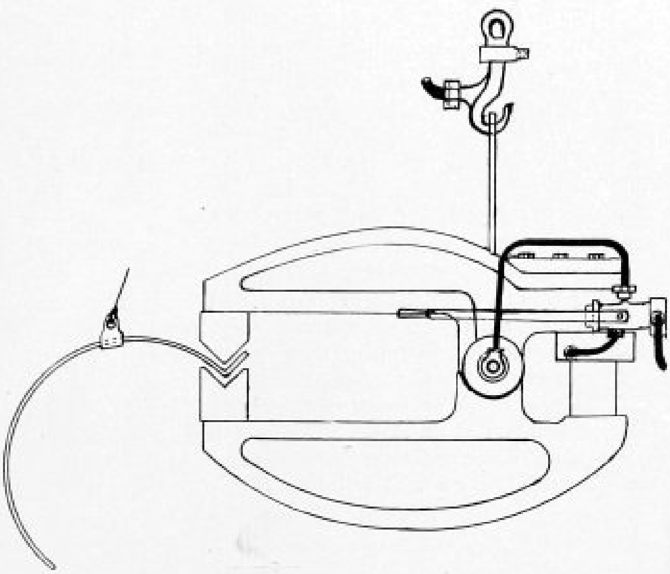


FIG. 82.—PORTABLE HYDRAULIC RIVETER USED FOR FLANGING.

Plates up to ½ inch or 9/16 inch thick and any length can be thus flanged, without buckling, by just working along and bending the plate gradually as in hand flanging, the difference being that the plate is squeezed down cold instead of being hammered.

This machine can also be equipped with circular blocks for setting up the ends of shell plates previous to being rolled up. The shell plate can be laid on trestles, and the machine made to travel along the two ends of the plate, thus squeezing it to the required radius, and doing away with a lot of sledge-hammer work. The plates for Adamson flues, after they are planed and beveled for welding, can be set up quickly along the ends in this way, and then rolled up and welded at the joint. Fig. 83 shows one section of a flue set on trestles with the riveter equipped with dies for setting up the edge of the plate. The machine should be suspended from a small overhead crane.

Very few shops are equipped with hydraulic plate-bending machines. The rolls have to be used to set up the shell plates, leaving a flat piece at each end of the plate. This flat piece can be set up in the fixed riveting machine if the shop is not equipped with a portable machine. A cast-iron block or former can be bolted to the stake, and a piece of heavy bar, about 4 inches square by 15 inches long, can be used in front of the ram. This bar can be suspended from the crane by a piece of rope (Fig. 84). The shell plate, after being rolled up, is placed in the machine and slowly heaved up by the crane, the riveter squeezing all the time as the plate ascends. The plate is then turned around, and the same done to the opposite end as the plate is being lowered. This will set up the ends of the heaviest shell plates, bending them to the correct radius.

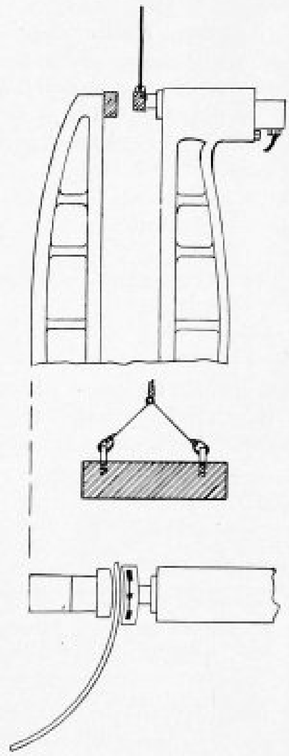


FIG. 84.—BENDING PLATES IN A STATIONARY RIVETER.

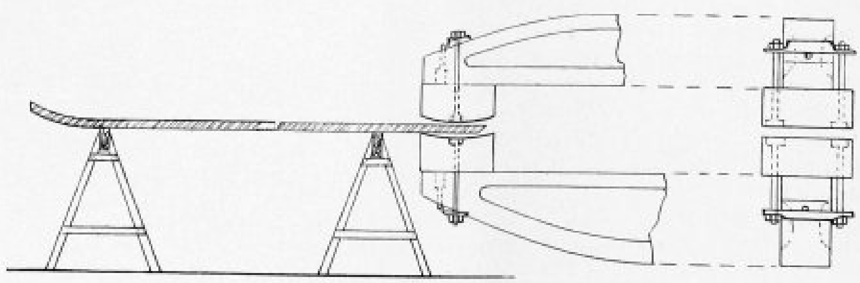


FIG. 83.—SETTING UP THE ENDS OF SHEETS WITH A RIVETING MACHINE.

Cone-shaped ends for digesters can be set up in the portable riveter. One style of end that requires only one seam is shown at Fig. 85. This plane has a hole punched out in the center. A piece is also cut out so that the cone will be the required diameter at the top and bottom and also the correct height, the plate is then fullered up by the use of formers in the riveter. These cones can also be set up to the required

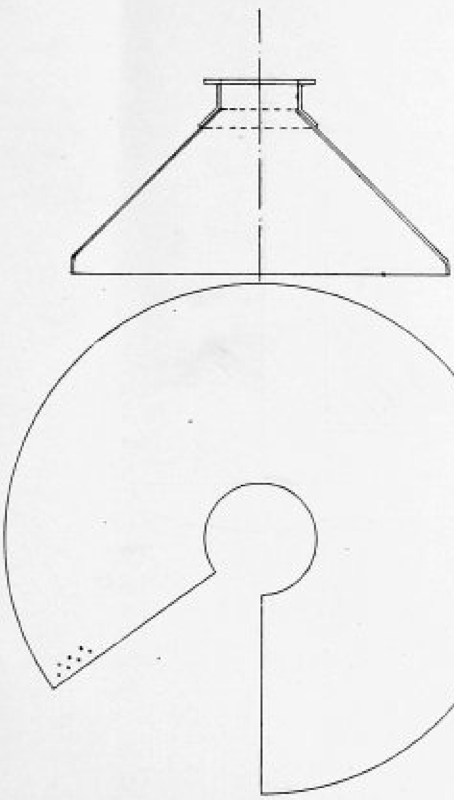


FIG. 85.

circle in the punch, if the punch is fitted up with dies. It is the usual plan to make these ends in sections. Some are made spherical, but a large number are cone-shaped. Some are fitted with castings having a flange at the end, others are flanged at both ends. Fig. 86 shows a half elevation of one type of head with the cone-shaped end flanged at both ends, one end to take the shell straps, and the small end a 6-inch by 6-inch

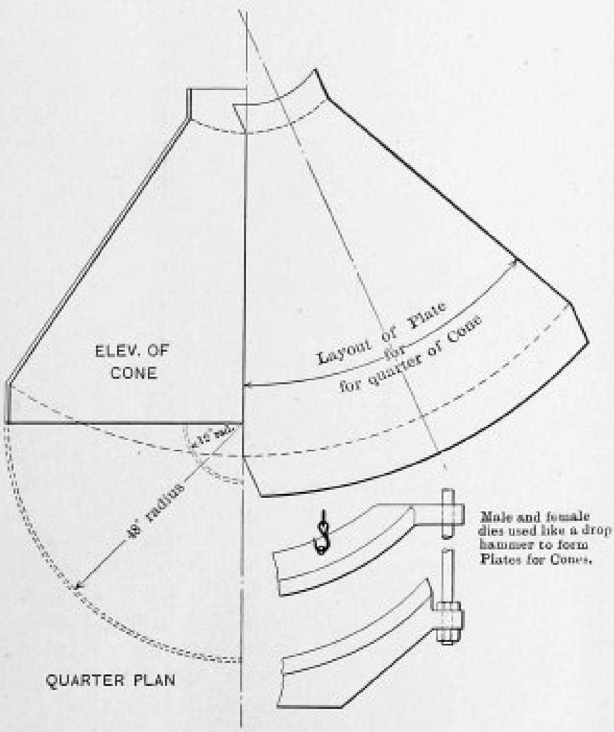


FIG. 86.

by ⅞-inch welded angle ring. This cone is 8 feet diameter at the large end and 2 feet diameter at the small end, and is made in four pieces with butt joints. The plate is 11/16 inch, and all the rivets are flush inside, the interior afterwards being coated with lead to keep the acid from eating the plate.

These plates can be formed to shape without the hydraulic press by using a male and female die the required shape. The female die is laid on the floor, the male die is heaved up by the crane and allowed to drop down on the hot sheet, thus forcing it into shape. To keep the dies in their correct positions relative to each other, four guide rods are employed; each guide rod is attached to a projecting lug at the corner of the female die, jam nuts being used. The rods thus project upwards, and pass through corresponding lugs in the male die, so that when the die drops it will coincide with the female die.

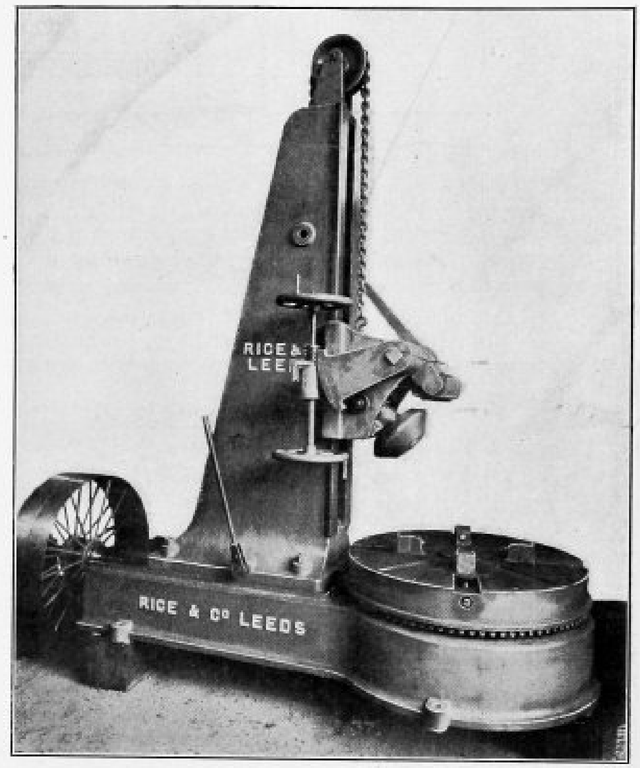


FIG. 87.—MACHINE FOR FLANGING SECTIONS OF ADAMSON FLUES.

Sections of Adamson flues are flanged on either belt or motor-driven machines. One type of machine has an inclined table or chuck on which a section of the flue is placed, the end to be flanged rests on and projects over two rolls of oval section. Another roll on top, also oval in shape, is fed down by a worm gearing and wheel, and turns the projecting plate down over the supporting rolls and forms the flange as the flue rotates. One of the latest of this type of flanging machines is shown at Fig. 87. The flue is quickly centered in the chuck, four steel-faced jams being so arranged that they all work out or in together. This machine will flange sections 24 inches to 48 inches in diameter, and from 12 inches to 60 inches in length, ¾ inch in thickness, and will turn down the flange true and square in about one minute.

Fig. 88 illustrates another type of machine for flanging boiler heads without the use of formers. The plate *P* is clamped between two discs, the edge of the plate projecting over a supporting roll *B*. A swiveling roll, which is carried in a movable housing, can, by the aid of the parallel levers, be made to travel from a horizontal to a vertical position by

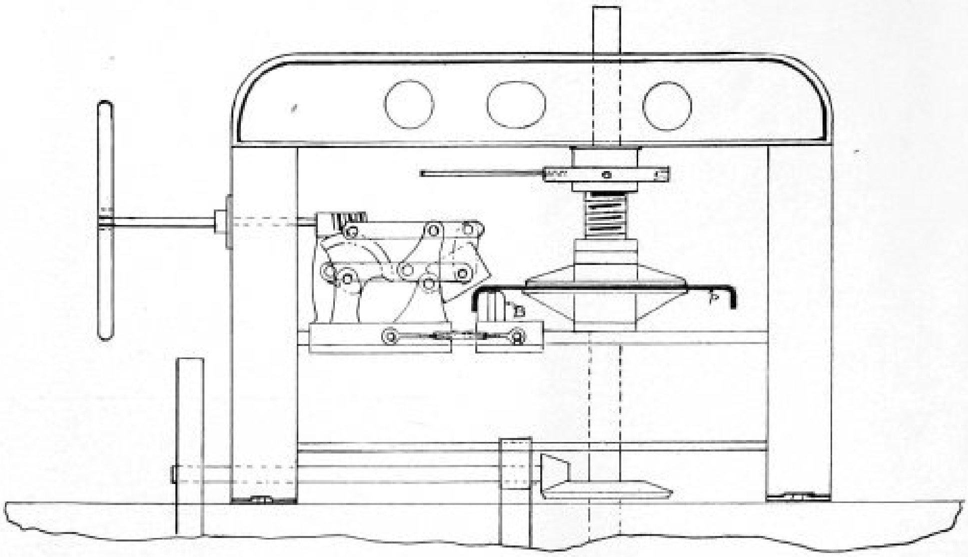


FIG. 88.—ROLLER FLANGING MACHINE.

turning the hand-wheel at the end of the machine when the plate is rotating. This swiveling roller is fed down on the projecting edge of the plate, and brings the plate down square over the roll *B*.

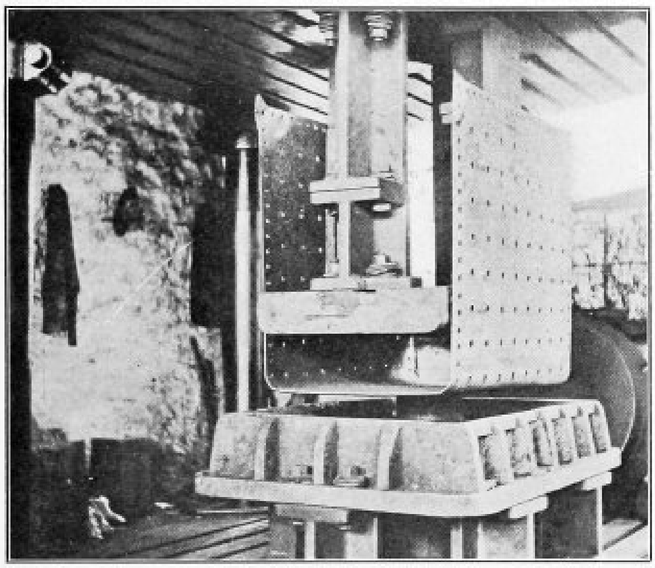


FIG. 89.

Another type of this machine has the swiveling roll underneath and a supporting roll of oval section above, and brings the flange up instead of down. The plate is clamped from above by an air clamp. Another interesting feature of this machine is the conical-shaped rolls, which can be forced under the head, and thus flanges and dishes the head at the same time.

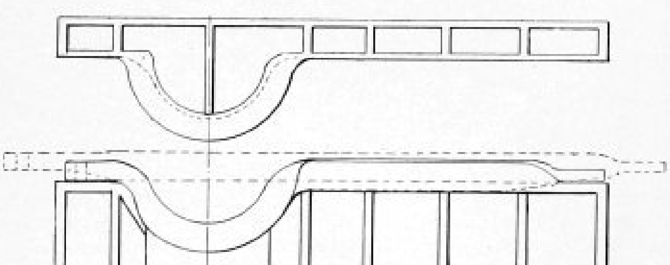


FIG. 90.

The photograph (Fig. 89) shows a flanged fire-box sheet for a locomotive-type boiler; the plate is 120 inches by 48 inches by 5/16 inch. The plate has just been flanged in the dies, and is bent to shape cold, and forms the sides and top of the fire-box.

In bending plates or bars cold there is always a tendency to spring; after the pressure is removed it will be found that the sides of the plate are not parallel. To overcome this the male die should have clearance on the sides. This clearance will cause the sides to incline toward each other when pressed down into shape. When the pressure is released the sides will then spring outwards and will be parallel.

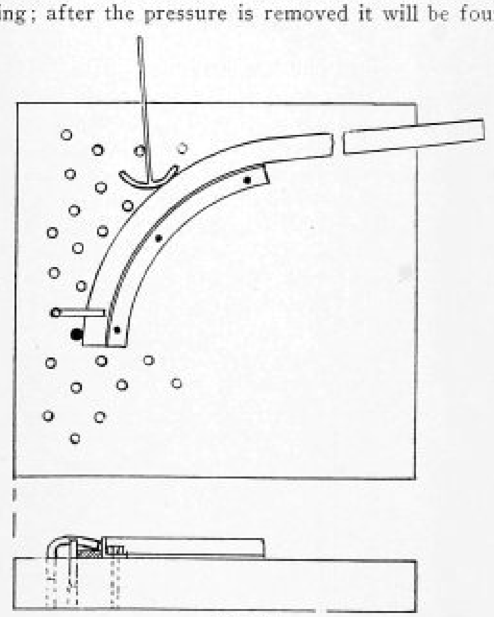


FIG. 91.

Many bending operations may be done on the press. Heavy goosenecks or frames, such as are sometimes used on fire engines, are bent either on a large bulldozer or in the hydraulic press. Fig. 90 shows the dies bending these forgings in the press. They are heated in the furnace, and are set on the dies to the center of the bend, so that both ends will draw easily into place.

Rings such as are used on Adamson joints are often bent by hand. Fig. 91 shows the usual method of bending them. A piece of angle or flat bar of the required shape is bolted to the block, the bar is heated and pulled around this angle-bar. A lever shaped like Fig. 92 is employed to squeeze any high places, and make the ring a true circle. Special rolls are made for these rings. These rolls have a groove in them to take the bar and hold it on edge while passing through the rolls. Another plan is to use the plate rolls to bend these rings; two angle-bars, suitably braced and bolted to the floor, will keep the ring upright as it passes through the rolls (Fig. 94). The bars are rolled up cold; and should they by chance get a little buckled or twisted, they are easily lifted out of the rolls and laid on the flattening block and given a few blows with a sledge hammer and then rolled up true. If the shop equipment includes a bulldozer, these rings can be quickly bent to shape. Each stroke of the machine will set up 18 to 24 inches. Fig. 95 shows this machine equipped with male and female dies; a ring is just finished on the machine and ready for welding. Fig. 93 shows a complete portable hydraulic outfit with a vertical boiler, pumps, accumulator, crane and a riveting machine of the hinged type. This will give the reader some idea what is required in a hydraulic installation. Steam, generated in the boiler, drives the pumps. These in turn raise the accumulator. The weight of the accumulator gives the necessary head or gives the required pressure in the pipes, generally 1,500 pounds per square inch. This pressure acting on the larger area of the ram gives the necessary pressure on the dies. Accumulators are sometimes made up of a series of large cast-iron weights, that can be reduced in number or added to as the pressure requires. More often in large installations the accumulator is a large steel tank, weighted down with scrap, and the machines are fitted with valves for different pressures, thus doing away with any changes on the accumulator.

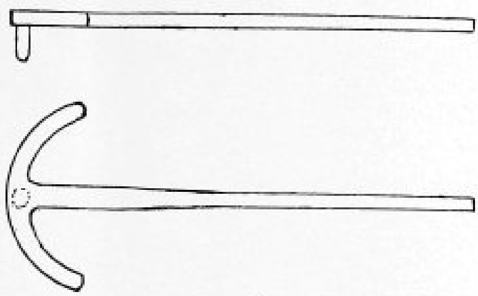


FIG. 92.

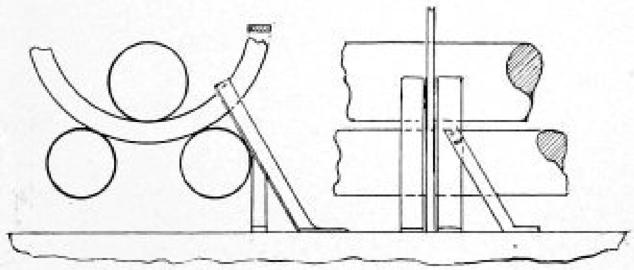


FIG. 94.

Plates to be flanged should be heated all over, preferably in a plate furnace. The ideal heat is a red heat, not a brilliant red turning to white, but a red heat with as little scale on the plate as possible. If the plate is only partly heated for flanging, it should be heated all over before being finally fitted in place, so that all internal strains may be released from the metal.

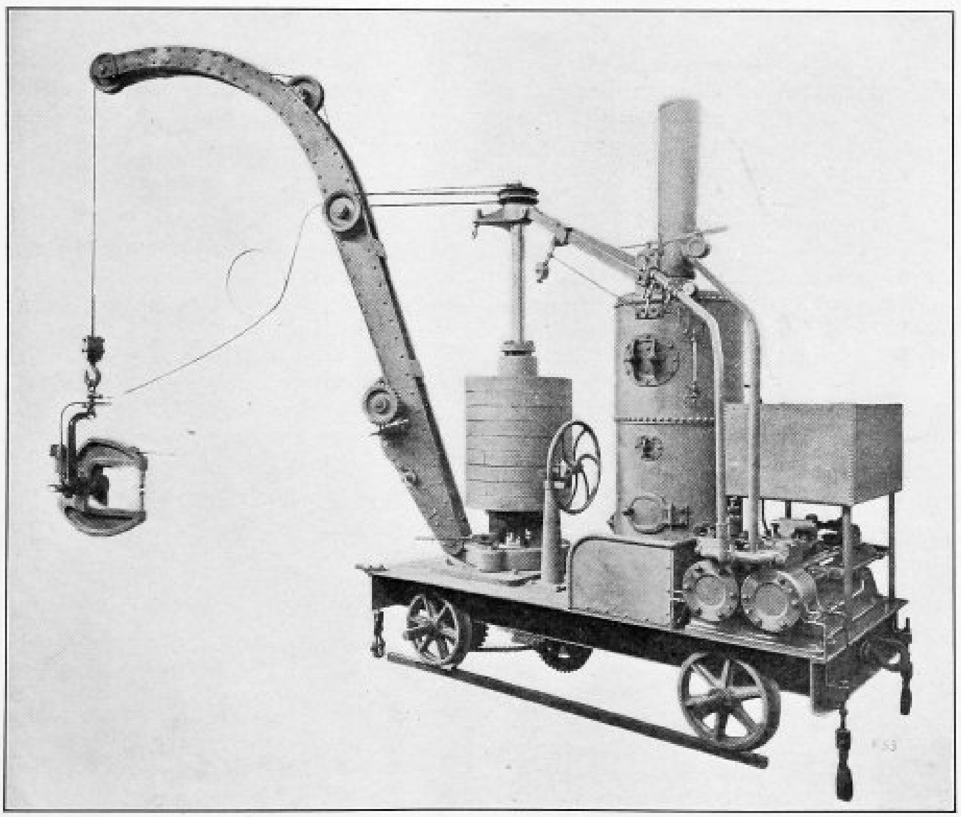


FIG. 93.

Another matter that should receive very careful thought is the placing of the hydraulic press and furnace so that the best service can be got out of them. These cannot be easily moved again, and too often one finds that the furnace has been placed in one corner of the shop and the flange press in another corner. The best output can be obtained from a furnace with a door at each end, so that the plates can be fed in at one end and taken out at the opposite end. One squad can then feed in the plates. This will enable the flange squad to get the maximum output from the flange press.

The hydraulic press should be set about 15 or 20 feet from the furnace door and directly in front of it. It should be set lower than the level of the furnace floor, and should have

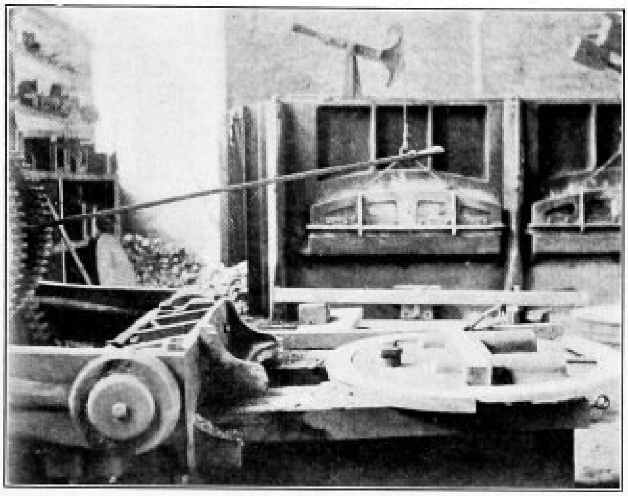


FIG. 95.

a good clear working space all around. The best runway for delivering plates from the furnace door to the press is made of channel or flat bars, with wheels between the bars. Wheels 6 inches diameter by ¾ or 1 inch thick will be suitable. Where light plates are handled a bar shaped like a fork and suspended by a chain is a good way of taking them from the furnace and placing them on the dies. Where heavy plates are handled a good overhead crane is a necessity. A 3 or 5-ton geared air hoist, suspended from a beam, can be used to handle the plates and dies. If used with a snatch block it will pull the heaviest plates from the furnace to the press.

A NEW DEPARTURE IN FLEXIBLE STAY-BOLTS*

BY H. V. WILLE.

There is practically no literature on the subject of stay-bolts, and this is particularly true of flexible stay-bolts. The increasing size and pressure of boilers make this subject of vital importance to railroads and to those responsible for the management of that type of boiler in which the fire-box is stayed by a large number of bolts.

The boiler of the consolidation locomotive, now the prevailing type in freight service, contains about 1,000 bolts less than 8 inches long and about 300 of greater length. The large types of Mallet compound locomotives now meeting with much favor have a much larger number, there being 1,250 short and 300 long bolts in locomotives recently constructed.

In recent years some form of flexible stay-bolt, that is, one having a movable joint, has been very extensively used in the breaking zone of locomotive boilers, but their high cost and the difficulty of applying them, their rigidity from rust and scale, and the fact that their use throws an additional service on the adjacent bolts because of lost motion, has militated against their more general use.

* Presented before the American Society of Mechanical Engineers.

It is well known that stay-bolts fail, not because of the tensional loads upon them, but from flexural stresses induced by the vibration resulting from the greater expansion of the fire-box sheets than of the outside sheets, but notwithstanding the general acceptance of this theory, engineers have designed stay-bolts solely with respect to the tensional loads. It is quite general practice, it is true, to recess the bolts below the base of the threads, and this has effected a slight reduction in the fiber stress, but practically no effort has been made to design a bolt to meet the flexural stresses or even to calculate their magnitude. This is surprising, in view of the simplicity of the calculations to which the ordinary formulæ for flexure apply.

Let

F = fiber stress.
E = modulus of elasticity.
I = moment of inertia.
D = diameter.
N = deflection.
L = length.
W = load.

We then have

$$W = \frac{2FI}{DL} \qquad (1)$$

$$N = \frac{WL}{3EI} \qquad (2)$$

Substituting

$$N = \frac{2FL^2}{3ED} \qquad (3)$$

$$F = \frac{3EDN}{2L^2} \qquad (4)$$

This formula shows that the stress increases in direct proportion to the diameter and decreases as the square of the distance between the sheets.

The application of the formula to service conditions gives the following stresses:

Conditions: Bolt spacing, 4-inch centers.
Assumed expansion, 4/100 inch.
Length of bolt, 6 inches.

TYPE.	Diameter of Bolt.	Flexural Stress.
Iron	1¼ inch	51,500
Iron	1 "	45,000
Iron	⅞ "	39,400
Spring steel	1 " ends $^7/_{16}$ inch stem	19,700

Iron is universally employed in the manufacture of these bolts, and it is not good practice to exceed a fiber stress of 12,000 pounds per square inch. It is apparent that stay-bolts in the zone which meets the expansion of the sheets are stressed above the elastic limit and must necessarily fail from fatigue. Fractures always originate at the outside sheet at the point where the bending moment, due to the movement of the furnace sheets, is greatest.

The fractures are in detail, usually starting from the base of a thread and gradually extending inward. Manufacturers of stay-bolt material have endeavored to minimize failures, and to meet the unusual conditions of an iron stressed beyond its elastic limit by the supply of specially piled iron, arranged with a view to breaking up the extension of the initial fracture. For this reason iron piled with a central section of small bars and an envelop of flat plates has met with much success for this class of service. In a further effort to secure an iron specially adapted to this class of work various forms of shock, vibratory and fatigue tests have been imposed. No design has yet been produced, however, which permits the employment of material of elastic limit sufficiently high to resist the flexural stresses, although a large class of material particularly adapted to the purpose is available.

It is obvious that the remedy does not lie in the use of a slow-breaking material, but in the employment of material of sufficiently high elastic limit to meet the conditions of service.

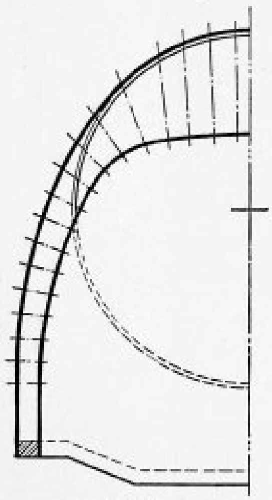


FIG. 1.

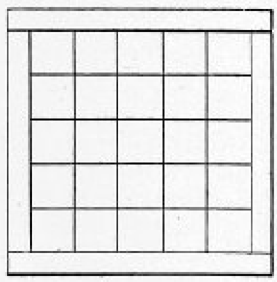


FIG. 2.

It is also possible to reduce the diameter of the bolt greatly by the use of such a material, thus proportionately reducing the fiber stress in flexure.

Stay-bolt material, however, must possess sufficient ductility to enable the ends to be readily hammered over to make a steam-tight joint, and to afford additional security against pulling through the sheets. To meet these conditions the bolt illustrated in Fig. 3 has been designed. The stem is of the same grade of steel as that used in the manufacture of springs. It is oil-tempered, and will safely stand a fiber stress of 100,000 pounds per square inch. Its high elastic limit makes it possible to reduce the diameter to ⅜ or 7/16 inch, or even less. The ends are of soft steel, and it is thus possible to apply and head up the bolt in the usual manner.

The employment of a stem of the diameter indicated reduces the fiber stress in flexure to less than one-half that in the ordinary type of bolt, and it is of material capable of

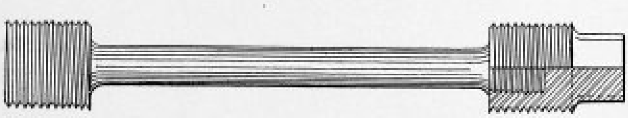


FIG. 3.

being stressed to a high degree. It has hitherto been impossible to employ in stay-bolts any of the steels containing chromium, nickel, vanadium or other metaloid possessing properties especially adapted to this class of work, but these steels can readily be used in the stem of the bolt described.

The stem of the bolt can be flexibly secured to the end in one of the customary ways, but the flexibility of the bolt does not depend upon a flexible connection. A type of bolt with a relatively inflexible connection, usually one in which the stem screwed into the ends with a running fit, met with the most favorable consideration. Such a bolt is flexible as a spring is flexible, in that it can be deflected to meet the requirements

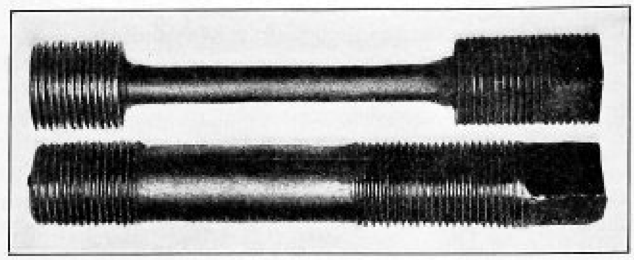


FIG. 4.

of service without exceeding the elastic limit. In fact the stem may be of a number of pieces, either of plates or small rods, thus increasing its flexibility.

The actual breaking strength of the bolt sizes ordinarily employed is shown in the following statement. These bolts were recessed to the base of the thread and tested in the same form as that in which they are employed in service. For comparison, the approximate weights of the usual length of bolt are also given. These weights are for bolts over the entire length, including the squared ends for screwing the bolts into the sheets:

ACTUAL BREAKING STRENGTH OF STAY-BOLTS.

TYPE.	Nominal Diameter.	Actual Breaking.	Weight.	Vibrations.
Iron...............	1 inch	32,500	20 oz.	6,000
Iron...............	$\frac{7}{8}$ "	24,500	15 "	5,200
Spring steel stem...	1 " ends $^7/_{16}$ inch stem	32,000	10 "	500,000

The vibrating test was made by clamping one end of the bolt in a machine and revolving the other end through a radius of 3/32 inch, the specimen being 6 inches long from

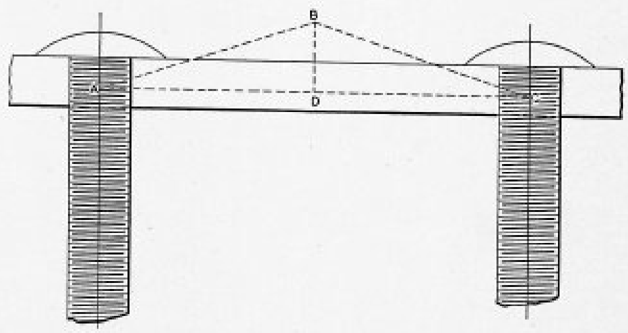


FIG. 5.

the end of the right head to the center of the rotating head. A tensional load of 4,000 pounds was also applied to the bolts. The best grades of iron bolts break on being subjected to from 5,000 to 6,000 rotations, whereas the spring steel bolts were vibrated 500,000 times without failure, and on some of them the test was continued without failure to 1,000,000 vibrations. These tests demonstrated that the bolt is not stressed beyond the elastic limit under these severe conditions, and that the probability of its failure in less severe conditions is very remote.

The extent of the expansion which can take place in the fire-box of a boiler can readily be calculated:

Distance between stay-bolts, 4 inches.

Temperature of inside sheet, 400 degrees F.

Temperature of outside sheet, 100 degrees F.

Coefficient of expansion, 0.0000066.

Then the expansion between two bolts will equal $0.0000066 \times (400 - 100) \times 4 = 0.0079$, and each bolt will deflect 0.00395 inch. It has been shown that this amount of deflection will stress the usual type of bolt beyond the elastic limit. In practice, however, one bolt may hold rigidly, throwing the entire deflection on the adjacent bolt, or neither bolt may deflect and the sheet will then buckle. Under this condition the neutral axis will assume the form *ABC*, and the length *AB* will equal 2.00395 inches, and the sheet will buckle to an extent, $BD = \sqrt{2.00395^2 - 2^2} = 0.125$ inch. It is obvious that the repetition of a force sufficient to buckle a sheet ⅛ inch must ultimately lead to a crack in the furnace sheets. If, however, the bolt deflects, allowing the sheet to normally expand, the latter will be relieved of these extraneous loads.

A bolt of sufficient flexibility to deflect under the forces following expansion, and of material which will not be stressed beyond the elastic limit in resisting these forces, will greatly assist in reducing the cost of boiler maintenance by eliminating broken stay-bolts and reducing the stresses in the furnace plates. If in addition the bolt has a smaller diameter the life of the furnace plates should be further increased, as such a bolt will interpose less obstruction to the circulation of the water in the water legs.

STANDARD PUNCHES, DIES AND COUPLINGS.

BY C. C. SWIFT.

Every shop that operates a punching machine uses punches, dies and coupling nuts of some description. The tools might have been of some known standard when the machine was purchased, but the question that should be looked into by the superintendent or foreman is whether they are standard at the present time or not. It seems to be the usual rule where companies make their own tools, unless special care is exercised, that each succeeding lot made up differs slightly from

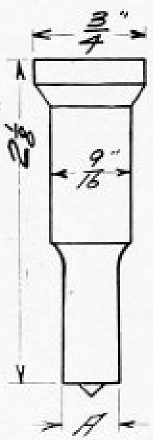


FIG. 1.

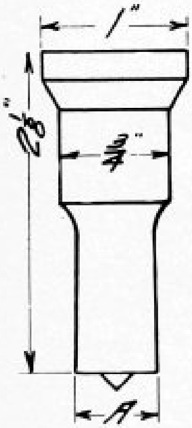


FIG. 2.

the previous lot, so that in the course of a few years the tools become special for that machine.

When a company operates more than one punching machine, and the above conditions prevail, the result is not merely continued annoyance but the added expense of having a stock of tools for each machine. A far better way is to arrange the machine to hold standard tools, so that the couplings, punches and dies used on one machine can be used on any other machine of like capacity in the shop. In doing this, it is advisable to adopt a standard which will permit the widest range of punching at the least cost. In other words, the most economical system is the one that requires the least number of punch stems and coupling nuts to accomplish a wide range of punching, it being understood that the punches are made out of the smallest amount of steel necessary, and that they conform to accepted designs.

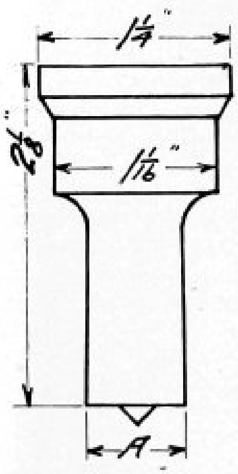


FIG. 3.

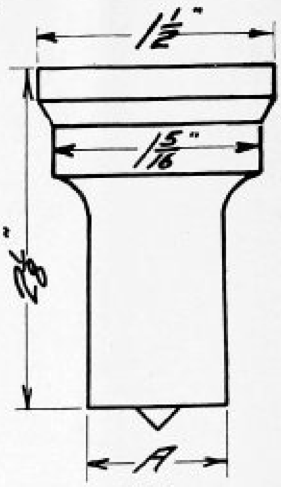


FIG. 4.

There is no question but that a company building punching machinery, and thus in close touch with requirements of such tools, should know what the trade desires. Punches are subjected to sudden and excessive shocks, and the ability to harden and temper tools of this description comes only after long years of experience in this class of work alone. In purchasing standard material, not only can you obtain a low price, due to the fact that such tools are made up in large lots, but you can get immediate delivery, and this latter feature generally means great saving.

In standardizing a machine it is necessary to design a punch stem that will permit the use of an economical punch and, at the same time, give a wide range of punching. Punches made out of ¾-inch stock, 1½ inches long, are the cheapest that

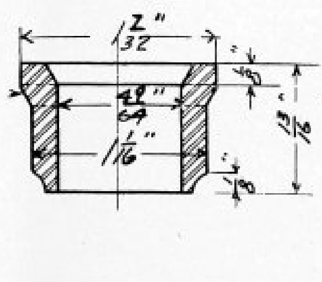


FIG. 5.

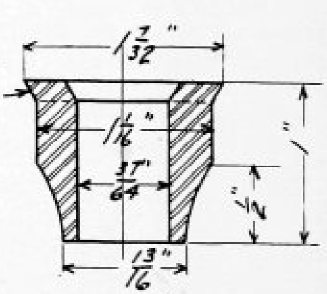


FIG. 6.

can be made for punching 7/16 and 9/16-inch holes; but if it is desired to punch 11/16 or 13/16-inch holes a new stem and coupling nut would have to be used.

If, however, a stem was designed to hold an economical 13/16 or 15/16-inch punch, a punch made out of, say, 1¼-inch stock, with a special arrangement for holding the smaller punches in the same coupling nut, would accomplish the desired result.

At the present time there are some half a dozen different standards established by different builders of punching machinery for punches, dies and couplings. While it would be of untold advantage to have a single standard, so that where a shop is equipped with several different makes of punches the same couplings, dies, etc., could be used on all, yet this is a condition which could only be brought about through the adoption of some standard by an association which is influential, not only in the boiler-making, but also in the structural, bridge and sheet metal-working shops all over the country. Since this condition is not likely to be fulfilled, at least for the present, boiler makers and structural steel workers can even now avail themselves of an economical standard for their punches, dies and couplings.

The illustrations are taken from the *Stocklist* published by the Cleveland Punch & Shear Works Company, Cleveland, Ohio, and show the manner in which this company has brought about standardization in its punches, dies and couplings.

Figs. 1, 2, 3 and 4 show punches suitable for punching holes from 1/8 up to 1 5/16 inches in diameter, Fig. 1 being used for

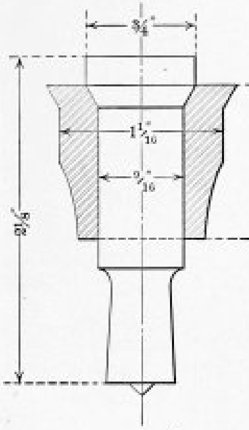


FIG. 7.

diameters from 1/8 to 9/16 inch; Fig. 2 from 5/8 to 3/4 inch; Fig. 3 from 13/16 to 1 1/16 inches, and Fig. 4 from 1 1/8 to 1 5/16 inches. Fig. 3 fits coupling nut No. 3 1/2, shown in Fig. 8, the shank of the punch being 1/64 inch less than the bore of the nut. The sleeve shown in Fig. 6 fits the punch shown in Fig. 1, as shown in Fig. 7. Similarly, the sleeve shown in Fig. 5 fits the punch shown in Fig. 2. These sleeves permit the use of coupling nut No. 3 1/2 with the punches shown in Figs. 1 and 2. There is no appreciable wear on these sleeves, so that they could be taken off a punch after it wears out and placed on a new one.

With the equipment noted, one stem and a No. 3 1/2 nut, the range of punching is from 1/8 to 1 1/16 inches, inclusive, and

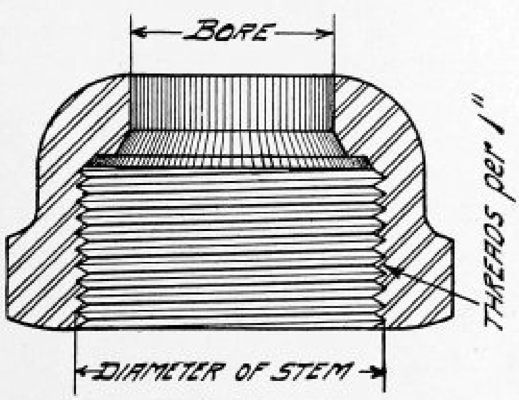


FIG. 8.—COUPLING NUT.

the small-diameter punches are made out of as little stock as is consistent with good design. If it is desired to punch holes from 1 1/8 to 1 5/16 inches, it is still unnecessary to change the stem. The result is accomplished by using the punch shown in Fig. 4, which will fit nut No. 3 1/2 if the bore is enlarged to 1 21/64 inches. This nut, with a 1 21/64-inch bore, is called nut No. 4.

The range of punching from 1/8 to 1 5/16 inches is accomplished on one stem, as has been described. If it is desired to punch larger holes, it will be well to take the matter up with a machine-tool builder, explaining the nature of the work, so that the punches may be manufactured in the most economical manner possible.

THE FAILURE OF BOILER PLATE THROUGH FATIGUE.

Many cases of failure of both iron and steel plates occur for which it is difficult to find a plausible reason. Subsequent physical and chemical tests of the metal may throw some light on the subject, though not always. A careful inquiry into the history of the plate from the time when it was first rolled up to the time of its failure may bring out some reason why there is a defect in the material. When none of these investigations provides a satisfactory explanation for the failure we are led to believe that the mere fact that the plate has been in use for a long time subjected to severe stresses, and stresses which are constantly changing in intensity, may have an ultimate effect on the structure of the material,

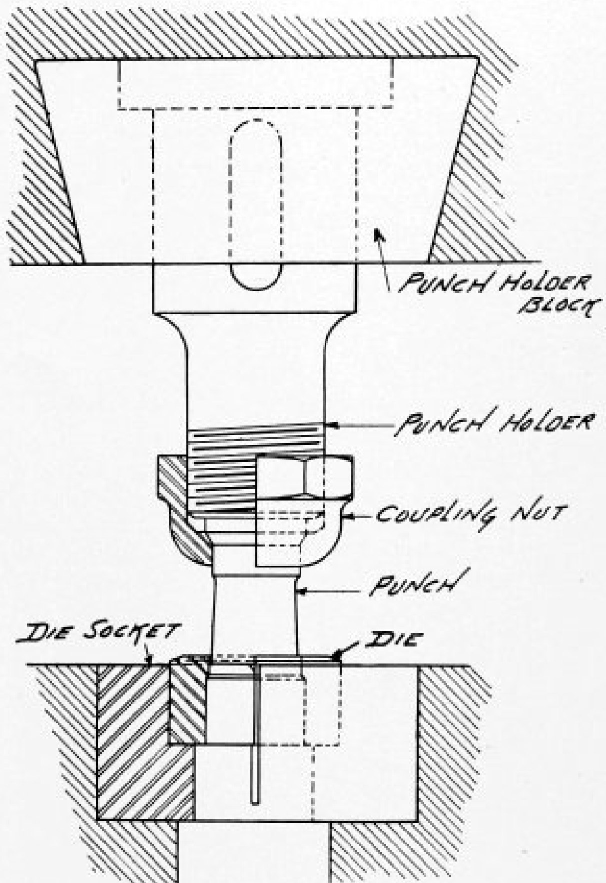


FIG. 9.—PUNCH, DIE AND COUPLING IN PLACE ON MACHINE.

causing the molecules to change their positions relative to each other and gradually changing the nature of the material itself.

A case of this sort occurred some time ago, and was thoroughly investigated by Professor J. A. Ewing and Mr. J. C. W. Humfrey. As a result of this investigation, the opinion was expressed that the fracture which occurred in a piece of Swedish iron was due to constant slipping in the crystals, which ultimately produced cracks in a cleavage plane. This constant slipping was occasioned by repeated alternations of stress on the iron.

Another case quite different from this was investigated by Mr. Sidney A. Houghton. The plate which failed was in the back ring of the shell of a portable boiler of the locomotive type which formed part of a steam ploughing engine. As a rule, the shell plates in a boiler are not subjected to fatigue stresses of importance, but in this particular case the step, or bracket, which carried the spindle winding drum was riveted

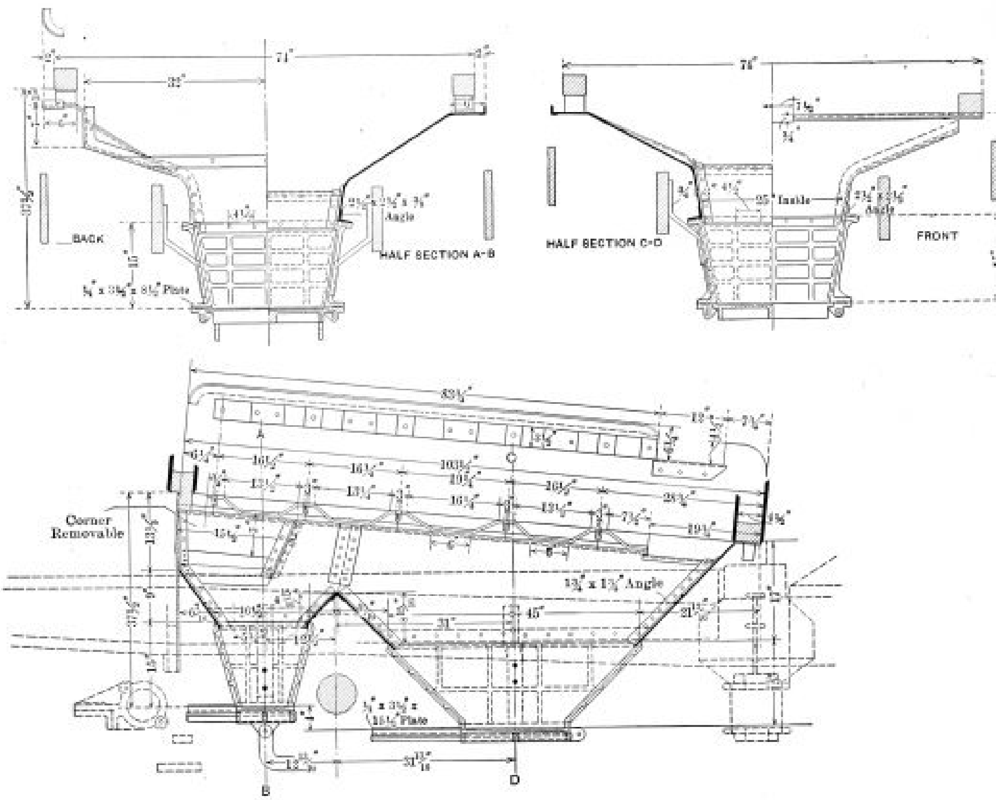


FIG. 1.—STANDARD TYPE OF SELF-DUMPING ASHPAN USED ON THE NORTHERN PACIFIC RAILROAD.

to it, and consequently, when ploughing was done, the plate was subjected to severe panting stresses. These stresses were, of course, in addition to the direct tensile stress, due to the steam pressure. The end of the step was riveted close to a longitudinal lap joint, so that these stresses were to a great extent localized, and, when the failure actually occurred, a crack was formed between the rivet holes in this joint. As is usually the case when a crack forms in a lap joint, it started from the inside of the outer lap of the plate, and consequently was not discovered, and the boiler exploded with great violence.

The boiler was about twenty years old, but, as it was in use only for a short time each year, the actual time it was at work was probably about six years. The shell plates were originally about 7/16 inch thick, but had wasted externally to about 9/32 inch near the point where the failure occurred, consequently the stresses at this point must have been gradually increasing in intensity. The chemical composition of the plate was as follows: Carbon, a trace; manganese, a trace; sulphur, .023; phosphorus, .310; silicon, .180 percent. The phosphorus is high and the silicon somewhat more than usual.

A tensile test on a specimen cut lengthwise of the plate near the fracture showed 53,000 pounds per square inch, with only 2 percent elongation in 1½ inches. The fracture was of a coarse crystalline nature. The metal was distinctly hard, and several sections which were cut from the plate showed

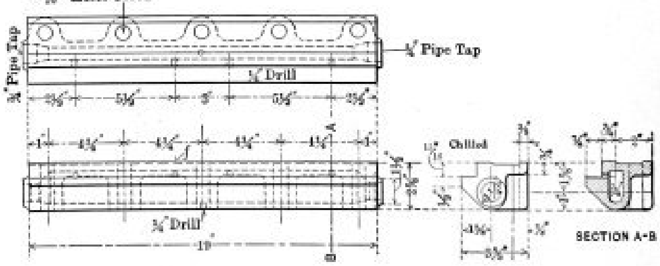


FIG. 3.—DETAILS OF STEAM-CORED SLIDE GUIDE.

that the structure was fairly uniform in all the longitudinal sections. There were large ferrite crystals and a considerable quantity of slag flaws. The rivet holes had been punched, and, notwithstanding the fact that this was done twenty years ago, the effect on the structure in distorting the neighboring crystals was apparently as clear as if the plate had just come from the machine. Although the failure took place between the rivet holes, numerous small cracks parallel to the line of fracture had formed on the inside of the plate. The cracks began at the surface, where it was fairly straight, but it is probable that this part was influenced by pitting.

The conclusions which can be drawn from this investigation are that fatigue stresses cause the formation of cracks, which,

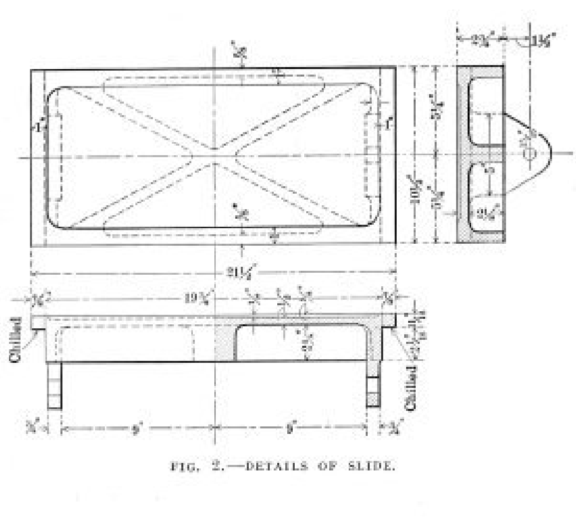


FIG. 2.—DETAILS OF SLIDE.

as a rule, begin from irregularities on the inner surface, and that the cracks are due to weakness in the cleavage planes of the crystals from continual slipping, and to some extent to the loss of adhesion between the crystals.

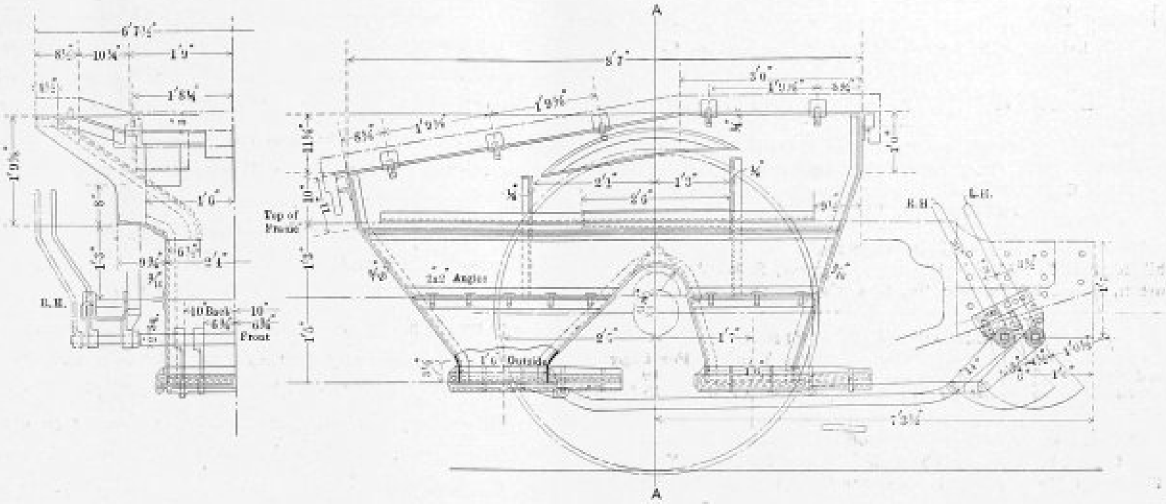


FIG. 4.—SLIDE-BOTTOM PAN USED ON THE CANADIAN PACIFIC RAILROAD.

SELF-CLEANING ASHPANS.

Fig. 1 shows the style of ashpan which is the standard arrangement for all new power on the Northern Pacific Railway. This design has been in operation for some time, and has been giving very good satisfaction. A slide-bottom pan is used on this road, for the reason that it has been found that less fire can drop out of the pan with this arrangement than with a drop-bottom pan, where the bottom bears up against the pan. The road runs through a great deal of dry country, and it is necessary to do everything possible to eliminate fire risk. Previous to the use of the sliding pan a great deal of loss was occasioned by burning bridges. It is understood that this has been largely overcome by using this type of ashpan.

It will be noted that a cast-iron hopper is used on this pan with sliding doors at the bottom. Details of the slide are shown in Fig. 2, while the slide guide is shown in Fig. 3. The guides are cored and tapped at the end for a ¾-inch pipe. In cold weather steam is admitted to this space to keep the slides from freezing up, and thus preventing their operation.

Figs. 4 and 5 show two types of self-cleaning ashpans which are used on the Canadian Pacific Railway. One of these is equipped with sliding doors and the other with drop doors. It has not been conclusively proved as yet which type is best suited for this particular railroad. Some claim that the sliding-door type will not be suitable for exceptionally cold climates, although they are provided with steam cores in the guides. Another valuable feature incorporated in these designs is the independent operation of the doors. This is a feature which will probably have to be adhered to, as it is not likely that the operation of two or more doors by one lever will prove satisfactory. If one door can be shut, it is obviously a good plan to shut it and then turn to the next door, which may be prevented from closing by a piece of ice or a mass of frozen cinders.

The pan shown in Fig. 5 is a drop-bottom pan, employing the same features as that shown in Fig. 4, with the exception that drop-bottom doors are used in place of sliding doors. This design also involves another feature, which, it is claimed, will be found necessary, and that is the inclination of the plane of the doors. If the doors are horizontal and the cinders become frozen into a solid mass, it would be very difficult to get at them with a bar in order to break them up; whereas if the doors were inclined, as shown in Fig. 5, it would be an easy matter to get at the frozen cinders, or ice, with a bar, and free the pan of all obstructions, so that the doors could be closed.

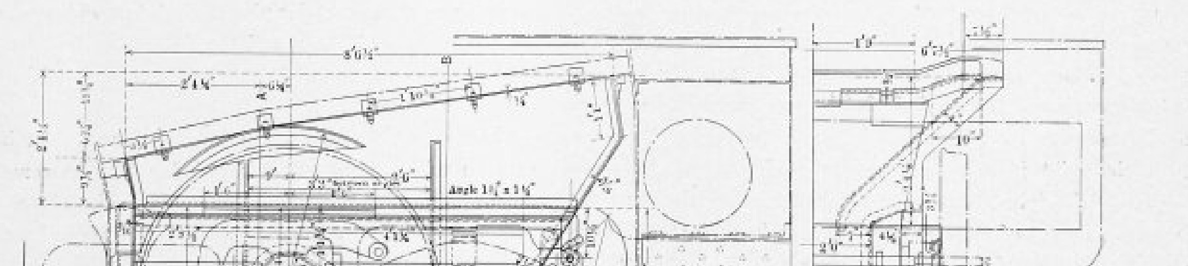


FIG. 5.—DROP-BOTTOM PAN USED ON THE CANADIAN PACIFIC RAILROAD.

The Boiler Maker

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NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

The edition of this issue of The Boiler Maker comprises 5,500 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

Last Month of the Prize Contest.

Before the next issue of THE BOILER MAKER is mailed our contest for the best articles on boiler repair jobs will have closed. Twelve o'clock noon, March 1, 1909, is the latest date on which papers submitted for this contest will be considered.

The conditions of the contest, as described in our November, 1908, issue, limit all articles to a description of some particular repair job, such as would be undertaken in a boiler shop or by boiler makers. It may be a case of repairing a boiler, stack, tank or any other article which is made in a boiler shop; but the main point is that the article should describe fully the nature of the job, the way in which it was carried out, the approximate cost of material and labor, tools used, etc. Where possible, photographs and drawings should be sent with the article for purposes of illustration.

After March 1 these papers will be submitted to a committee consisting of Col. E. D. Meier, president of the American Boiler Manufacturers' Association; P. J. Conrath, president of the International Master Boiler Makers' Association, and J. T. Goodwin, chairman of the executive committee, International Master Boiler Makers' Association, which will report its decision at the forthcoming convention of the International Master Boiler Makers' Association, to be held at Louisville, Ky., April 27, 28, 29 and 30. First and second prizes of $40 and $25, respectively, will be awarded to the men who, in the judgment of the committee, have written the best articles on this subject. One man may send in as many articles as he desires; they should not, however, be signed by the competitor's name, but should bear some distinguishing mark, and the name of the author be inclosed in a sealed envelope, bearing a duplicate of this identification mark. All articles written for this contest will be published either in full or in abstract form in later issues of THE BOILER MAKER.

Some Things a Boiler Maker Should Know, and Why.

After serving an apprenticeship of four or six years in a boiler shop the average man is qualified to carry out, under the direction of others, most jobs which come up in the shop. Unfortunately, however, through his course of apprenticeship training he has learned little except the actual shop operations. As far as the theory of the generation of steam and the design of boilers are concerned, he is little better off than when he entered the shop, unless, through his own efforts, he has made a study of these subjects. So far in his experience he has probably not found it necessary to know very much about the theoretical side of boiler making, but, if he is to advance any further and become a layerout, foreman or superintendent, he will find that practical experience alone is not enough in most cases to qualify him for such a position.

The first promotion which is likely to come his way is a job at the laying-out bench. To make a success of laying out he must acquire some knowledge of drawing and elementary geometry. From the simplest operations of laying out, such as squaring up a sheet, to the development of the most complicated line of blast-furnace piping, there are a few fundamental principles of geometry which he must know, as well as a few simple calculations, such as finding areas, volumes, estimating weights, etc. Even after becoming thoroughly acquainted with the subject of laying out, he will find that so far his work has simply been the development of the ideas and designs of the draftsman or engineer of the plant. His work has begun only after the complete designs are made, and practically all he has to do is to transfer these designs from blue prints to the material used. To go further, he must know something of the underlying principles which govern the design of steam boilers, and the first thing he must learn is how to figure the strength of a boiler or tank subjected to an internal pressure.

Calculations for the strength of boilers cannot be intelligently made without a full knowledge of the strength of the materials used in their construction. Therefore, a boiler maker should have a general idea of the chemical composition and physical properties of steel, wrought iron, cast iron and the various other materials which enter into the construction. Having gained a definite idea of the strength of materials, he can attack the calculations which determine the strength of the boiler. The strength of cylindrical shells, riveted joints, flat surfaces, stays and braces all present different problems which must be solved before the strength of the entire boiler can be calculated. Beyond this there is the determination of the size and power of boilers, the analysis of fuels, the process of combustion, the theory of the transfer of heat from hot gases to the water, as well as the action of corrosion, formation of scale, etc.

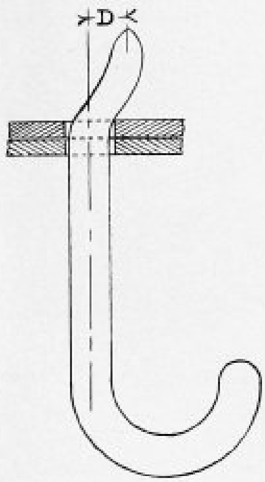
These are some of the more important things which a boiler maker should know, and these we intend to take up more or less completely during the coming year, so that along with practical discussions of shop work our readers may have an opportunity to learn much that relates to the so-called theoretical side of boiler making.

COMMUNICATIONS.

A Holding-on Hook.

EDITOR THE BOILER MAKER:

Undoubtedly many boiler makers have had a great deal of trouble in using a hook to support a holding-on sledge where it is necessary to place a nut on the end of the hook to hold it in place. The sketch shows a simple expedient which makes it unnecessary to use a nut on the end of the hook. All that is



IMPROVED HOLDING-ON HOOK.

necessary is to offset the upper part of the hook the thickness of the rivet, provided the hook is made the same diameter as the rivet. The use of this hook will result in a great saving of time and trouble, for the holder-on can easily move it from one hole to another, and thus get the best position for holding on the rivet. J. H. BONDY.

Foreman Boiler Maker, Boston, Montana, C. C. & S. N. Co.

Charcoal Iron Boiler Tubes.

EDITOR THE BOILER MAKER:

The statement has of late frequently been made that there is no charcoal iron at the present time being used in the manufacture of boiler tubes, the material parading under that name being a conglomeration of steel and iron scrap, such as would result from a busheling operation, where the heated and unmelted charge is simply welded together. To a metallurgist, especially, this charge is absurd, but to one unfamiliar with the operation of the few charcoal-iron forges in this country, a brief description of the process may be of interest.

Of the tube mills possessing their own sources of supply in the shape of forge fires owned by themselves, there are the Parkesburg Iron Company, Coatesville Rolling Mill Company, and Tyler Tube & Pipe Company. Of the other mills producing charcoal-iron tubes, Spang-Chalfant & Company, Reading Iron Company, and Reliance Tube Company are able to secure from trustworthy sources either charcoal-iron blooms or skelp for tubes rolled from these blooms.

The modern charcoal-iron forge is in principle a duplicate of the old; in practice, the only change is in more careful inspection of the finished product, and in more careful selection of the charge, due to the fact that by chemical analysis any stock containing elements detrimental to the finished blooms can be eliminated. The charge consists, as in the past, of run-out metal, *i. e.*, pig from which the silicon has been oxidized, or of clean, finely divided wrought and steel scrap. The forge consists of the same flat-cast plates, arranged rectangularly, having the same relative positions to one another, and even the same names—as an example, the Merritt, known to every forgeman, is placed over the tuyere, the latter being adjusted at exactly the right angle, to allow the blast to work most effectually.

The forgemen themselves have, to a man, either been working the same way for thirty years or else are sons or grandsons of forgemen whose methods and manners they inherit, and whose habits are as fixed as the laws of the Medes and Persians. Even in the unit by which they are paid, the bloom ton of 2,464 pounds, there has been no change.

As to the process of manufacture, the operation of sinking the charge into a bloom consists of feeding the stock with charcoal into the fire, where by the blast every particle of the metal is melted and sinks to the hearth. A basic slag is engendered, the carbon, silicon and manganese are practically eliminated, and the sulphur and phosphorus very largely reduced. The metal, drop by drop, each encased in a filament of cinder, is "brought to nature," as in the puddling process, by the reducing flame, and collects into a ball consisting of pure fibrous iron sub-divided by a network of cinder, which is then shingled under the hammer into a bloom of strictly charcoal iron.

Regarding the boiler tubes made from this material, length of service, due to their non-corrosive qualities, has enabled them to survive against the competition of cheaper steel, and will make them more and more a factor where quality, not quantity, is considered. IRON WORKER.

TECHNICAL PUBLICATIONS.

Profit Making and Shop and Factory Management. By Charles U. Carpenter. Size, 5¾ by 8½ inches. Pages,, 146. New York and London, 1908: *The Engineering Magazine.* Price, $2 (8s. 6d.).

This work is a concise expression of the methods which the author has developed in connection with the National Cash Register Company and the Herring-Hall-Marvin Safe Company, of which latter he is president. The contents appeared first in the form of a series of articles in *The Engineering Magazine* during 1907. They have been carefully revised, somewhat enlarged and rearranged, and now divided into chapters. The work was produced in the midst of the author's labors in the management of a great manufacturing company, and was inspired by his keen interest in the promotion of better ideals in industrial organization.

It is divided into fourteen chapters, covering, respectively, the reorganization of run-down concerns; the practical working of the committee system; the necessity for reports and their uses; the designing and drafting department; the tool room; minimizing the time of machine-tool operations; the use of high-speed steel; the determination of standard times for machine operations; standard times for handling the work; standard times for assembling; stimulating production by the wage system; stock and cost estimates; the upbuilding of a selling organization, and effective organization in the executive department.

The work takes up the defects in the various departments and methods of overcoming difficulties of this character; and is illustrated simply by tables or forms for cards for recording work in its various processes through the shop. Stress is laid upon the importance of putting the work in control of competent men, no matter what salary may be demanded. It is shown to be more expensive, in the long run, to employ an incompetent man at a low salary than a thoroughly competent man at several times this figure. The whole keynote seems to be the obtaining of the best efficiency from every unit in the works, whether that unit be human or a machine built of iron and steel.

Patents as a Factor in Manufacturing. By Edwin J. Prindle. Size, 5 by 7½ inches. Pages, 134. New York, 1908: *The Engineering Magazine*. Price, $2.

This volume is not intended to give the inventor or the manufacturer sufficient information so that he may act as his own patent lawyer, but it is intended rather to convey an idea of the nature of a patent, the protection it may afford, the advantages it may possess for meeting certain commercial conditions, the safety which may be secured in relations between employers and employees, and the general rules by which the courts will proceed in upholding a patent and in thwarting attempts of infringement. It is intended to give the inventor or manufacturer a grasp of the fundamental principles, so that he may proceed rightly in the early steps which are usually taken before the advice of counsel is secured, after which it is pointed out when and where it is necessary to call in expert legal advice. The author of the book, as the result of wide practice, both in mechanical engineering and in patent law, is in a position to appreciate the important points of this subject, and place them before the reader in such a way that the precautions which should be taken in the preliminary steps, and the rules and principles which should be followed, are made clear. The book includes the following chapters: Influence of patents in controlling the market; subject, nature and claim of a patent; what protection a patent affords; infringements; patenting new products; patent relations of employer and employee, and contests between rival claims to an invention.

The Temperature-Entropy Diagram. By Charles W. Berry. Size, 4¾ by 7¼ inches. Pages, 299. Figures, 109. New York, 1908: John Wiley & Sons. Price, $2.

Students of thermodynamics are usually puzzled about the true significance of entropy, and frequently fail to realize the usefulness of the temperature-entropy diagram. This is the only book, so far as we know, which is devoted exclusively to the subject, presenting it in a clear and available manner. The subject matter has been gathered in an effort to bring together in logical order certain information concerning the construction, interpretation and application to engineering problems of the temperature-entropy diagram which is not readily accessible. An exhaustive treatment of the subject has not been attempted, but the graphical presentation of the subject given is such as to make clear the fundamental principles of thermodynamics.

The present volume is a revised edition, the first volume having appeared in 1905. A graphical method of projecting from the pressure volume into the temperature-entropy plane has been elaborated for perfect gases and its application to hot-air engines and gas engines given. The various factors affecting the cylinder efficiency of both gas and steam engines are thoroughly discussed. One chapter is devoted to the thermodynamics of mixtures of gases and vapors, and another to the description and use of Mollier's "Total Energy-Entropy Diagram."

Steam Power Plant Engineering. By G. F. Gebhardt, Professor of Mechanical Engineering, Armour Institute of Technology, Chicago. Size, 5¾ by 9 inches. Pages, 816. Figures, 461. 1908, New York: John Wiley & Sons. Price, $6.00 net; and London: Chapman & Hall, Ltd. Price, 25/6 net.

This book is the outcome of a series of lectures delivered to the senior class of the Armour Institute, and is primarily a text-book for engineering students, but also of interest to practicing engineers. The field embraced by the title is such a large one that it has been necessary to limit the treatment to essential elements only.

The work is divided into twenty-one chapters and six appendices, covering in rotation elementary considerations, fuels, boilers, furnaces and stokers, superheated steam, coal and ash-handling apparatus, chimneys, mechanical draft, steam engines, steam turbines, condensers, feed-water heaters, pumps, superheaters, piping, lubrication, finance and economics, instruments, typical specifications, a typical steam turbine station and a typical isolated station.

The work is full of references to original sources of information, particularly to current technical magazines; and the illustrations have been drawn from a great variety of sources, covering practice of all sorts all over the United States. Many of the illustrations are charts of performance, relating results to consumption of fuel and general cost of production and power.

In some respects the two last chapters, dealing, respectively, with the Commonwealth Edison Company, of Chicago, and the West Albany Power Station of the New York Central Railroad, are the most interesting of the work. Each deals with a thoroughly successful and up-to-date plant, the two plants considered being of totally different character, and markedly different in size. The installations are described in some detail, while the illustrations give a good idea as to the layout and general equipment of the plants.

The Mechanical Engineering of Power Plants. By Frederic Remsen Hutton, E. M., Sc. D. Size, 5¾ by 9 inches. Pages, 825. Figures, 697. New York, 1908: John Wiley & Sons. Price, $5.

A former edition of this book, issued in 1897, embodied the study and experience of the author, gathered during the previous twenty years, and brought together for teaching purposes. Due to the fact that the years since then have been a period of great and rapid progress in the development of the power plant, and of engineering departments pertaining to it, it has been found necessary to rewrite the entire book. The present edition is the result of this work.

The new features which are specially noteworthy are the analysis of the power plant and its diagram; the separation of the simple and complex phases of this problem; the treatment of the steam pipe as an element of co-ordinate importance in the plant with the boiler and engine; the chapters on the auxiliaries as distinguished from the essentials; a discussion of the steam turbine; the establishment of the philosophy of the expansion of the elastic medium as the basis for the valve gear, the governor, the condenser and the compound engine. Statistics and tables have been very largely excluded, it being the intention of the author that engineers' pocketbooks should be consulted for this information.

The main headings under which the subject is treated are the quantitative basis of the steam-power plant, leading up to the cost of a horsepower; a comprehensive treatment of the steam boiler, including all its accessory apparatus, care and management, piping, etc.; an equally complete treatment of the engine, including a description of the design of the ordinary reciprocating engine, the rotary engine, steam turbine, valve motions, governors, condensers and auxiliary apparatus. Considerable space is given to the care, management and testing of boilers, engines, etc.

Taken all in all, this is undoubtedly one of the most complete and valuable works covering the steam-power plant which is available for engineers to-day.

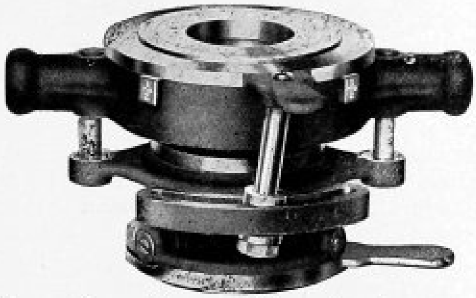
Omission.

In the article published on page 1 of our January issue, describing the Union Boiler Works, of Lebanon, Pa., we omitted to state that the hydraulic riveter, together with its pump and accumulator, which was described in the article, was manufactured by Joseph T. Ryerson & Son, Chicago, Ill.

ENGINEERING SPECIALTIES.

Oster Matchless Die Stock.

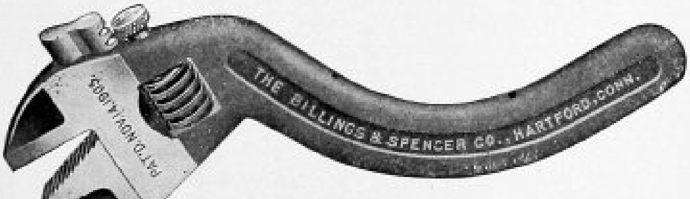
The Oster Manufacturing Company, of Cleveland, Ohio, has recently brought out a new tool for threading pipe. This is a die stock for pipe ranging in size from 1 to 2 inches in diameter. The dies are controlled by a cam, which, following the lead screw, is driven by a guide post at the exact taper for pipe thread. The dies automatically recede to make a standard taper thread. Standard size is obtained by setting



the guide post in position to indicate the size as graduated on the face plate, and locking the die solid by the nut at the bottom of the post. This setting remains unaltered as long as duplicate threads are desired. Over or under-size threads, or crooked threads, can be obtained if desired, and one set of dies may be used for all sizes or a set for each size, as the operator prefers. An important feature is the universal gripping chuck, which adjusts to all sizes by revolving a handle; this takes the place of all bushings and makes the stock entirely complete within itself. There are no loose parts, and as the gripping jaws are of tool steel, hardened, it is claimed that they will effectually withstand the strain and wear.

An Improved Adjustable "S" Pipe Wrench.

This wrench is a new product of the Billings & Spencer Company, Hartford, Conn., and in general design it follows the lines of their regular adjustable "S" wrench; but it has a serrated jaw for use on pipe. Every part is a drop forging from steel, and the jaws are hardened. The sliding jaw is



fitted in a double groove, which greatly adds to the strength of the tool. The patent thumb screw on the adjusting nurl securely locks the jaw at any desired opening.

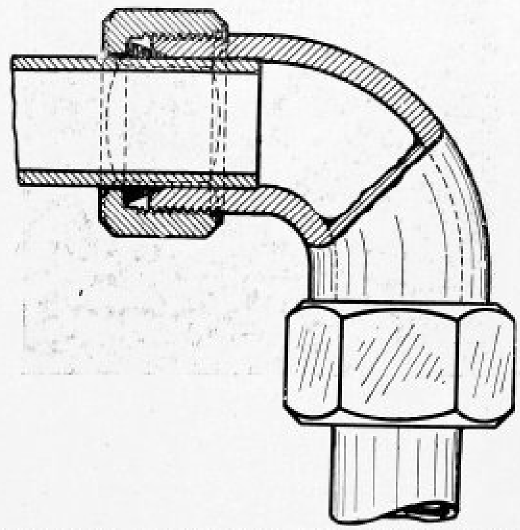
The wrench is made in three sizes, 6, 8 and 10 inches. It is of careful workmanship throughout, and its design is such as to make it very useful in confined places, where an ordinary wrench would be inconvenient.

The New Union-Cinch Pipe Fitting.

It is not an easy matter to make a neat job of pipe fitting with small piping where ordinary threaded pipe and tapped fittings are used. Where the work of threading the pipe and getting a good fit for the threads can be accomplished at a factory or in the shop, it is reasonable to expect that the work will be more satisfactory than when done by inexperienced workmen in the field without proper facilities.

The Union-Cinch pipe fitting, manufactured by the Sight Feed Oil Pump Company, Milwaukee, Wis., was designed so that the work of threading could be done in the shop rather than in the field, so that the only tools required in the field are a hack-saw and monkey wrench, except where some complicated bends are to be made when a pipe-bending device of some sort is necessary. Each fitting is a union, so that the piping may be taken down at any point where a fitting is inserted. The type of joint is clearly shown in the illustration. The joint is made by screwing down the outside nut, which presses a thin, tapered shell into an annular cavity around the pipe between it and the fitting. After these nuts are set up tightly the soft cone shell will make an absolutely tight joint around the tubing, capable of withstanding any pressure which the tubing will stand.

These fittings are made in sizes corresponding to standard iron pipe up to 1 inch, and are especially designed for use in connection with the oil pumps and oilers manufactured by the



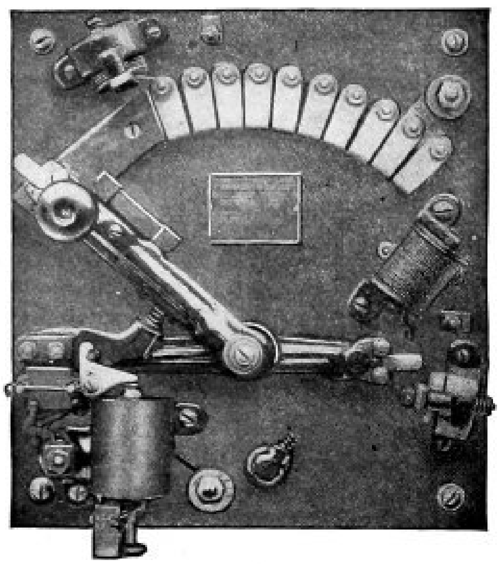
Sight Feed Oil Pump Company. It is possible, however, to use ordinary rough pipe with these fittings if care is exercised in filing the ends of the pipe round and smooth, but the manufacturers of the fittings are prepared to furnish smooth-drawn steel tubing corresponding to the iron pipe sizes on the outside diameter. This tubing has a 16-gage wall in the ¾ and 1-inch sizes, and an 18-gage wall in the smaller sizes. This pipe, therefore, has a very much larger carrying capacity than ordinary pipe. In fact, the manufacturers claim that their ⅛-inch pipe will carry almost as much as the ordinary ¼-inch iron pipe. Where it is desirable to have a nice-looking job, brass pipe may be used, although in cases where nickel plating is done a steel tubing will nickel-plate just as well as brass pipe, and is much cheaper.

These fittings are especially valuable in such troublesome work as piping up oil pumps, gravity oiling devices, gages, drop pipes, etc., and especially in work around ammonia-handling machinery, where perfectly tight joints are essential against the escape of ammonia gas.

Motor Starters for Motor-Driven Machine Tools.

When the practice of driving machine tools by electric motors was in its early stages of development, the motor was always belted to the machine tool. Now nearly all manufacturers have made the necessary provisions to connect the motor directly to the machine tool. Unless a necessary precaution is taken this method is a step backward. It makes a neater appearance and requires less space. However, if an overload occurs in the belted type, the slip of the belt would give some protection against breakage of the machine and the destruction of the motor. In the direct-connected type there is no such protection. Fuses are not reliable. They are expensive, and a great deal of time is taken in charging them. Usually extra large fuses are put in the circuit, and then there is no protection at all.

The necessary precaution to take, is to insert a magnetic overload circuit breaker in series with the motor. The Ward Leonard Electric Company, of Bronxville, N. Y., builds a magnetic overload circuit breaker as an integral part of a motor starter. This independent overload circuit breaker is so interlocked with the starter that the circuit breaker cannot be closed except when the starting arm is in an open circuit

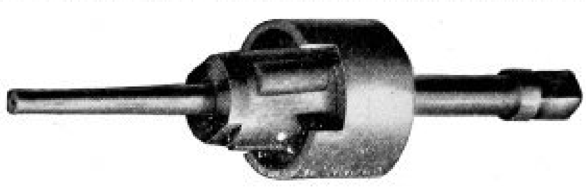


position. This is the equivalent of a double-pole, double-arm circuit breaker, in that the breaker cannot be closed except when the circuit is in a protecting position. Overload protection is given both during the period of starting as well as at all other times.

The greatest chance for overload in a motor circuit is during the period of starting the motor, *i. e.*, in accelerating the motor and machine tool from the inertia of rest to the speed required. Therefore, protection against overload during the starting period is very necessary; in fact, the United States government considers it so necessary that in their specifications for motor-driven apparatus they state absolutely that "an overload device which operates by short circuiting or opening the circuit of the radiating magnet of the no-voltage release will, under no conditions, be accepted." This is because such a device does not give protection during the starting period. Another important feature in the design of the starter, shown in the cut, is that the resistance elements are absolutely enclosed; metallic chips cannot fall in and dust cannot accumulate, causing short circuits.

A Ball-Bearing Self-Feed Expander.

In order to lessen the friction which occurs in the ordinary type of roller expander, Joseph T. Ryerson & Son, Chicago, Ill., have placed on the market a new ball-bearing expander of the self-feed type. The body of this expander is made from

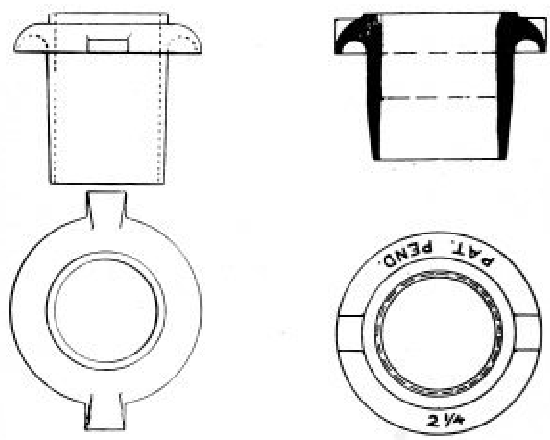


tool steel, carefully tempered. It has a ball-bearing back of the guide collar to prevent friction. The body of the tool is so constructed that the rolls cannot fall out upon the removal of the mandrel. The illustration shows the expander fitted with a square shank for power drive, but the tool is also furnished with round shank mandrels for hand power. The rolls are tapered, so that the expander is self-feeding.

Emergency Flue Nipple.

The Trenton Malleable Iron Company, Trenton, N. J., has recently placed on the market an emergency nipple made of malleable iron, tapered so that when it is driven into a flue it may be rolled or expanded in the usual way. The object of the emergency nipple is to prolong the life of the flues by taking care of leaky or injured flue ends. As shown in the illustration, the nipple is open, and therefore it does not reduce the heating surface of the flue, as a solid plug would do.

The object of this device is to make what is practically a hollow thimble, which may be readily put in or withdrawn from a locomotive boiler tube at the fire-box end when leakage has begun, or when the bead has burned away or otherwise damaged. It is designed to completely cover the damaged parts, and so add materially to the life of the flue as a whole.



Usually a damaged flue is stopped up with a solid plug, and while this avoids temporarily the removal of the flue, nevertheless the usefulness of the hollow flue is impaired because the hot gases can no longer pass through it. This not only lessens the heating surface of the boiler but also puts a tremendous strain on the flue-sheet bridges, so that if the plug is left in place it is usually not long before twenty or twenty-five more flues are plugged.

Since the emergency thimble or nipple is capable of being expanded or rolled in the flue, so as to make a tight fit, the leaky end of the tube is thus effectually sealed up. To facilitate the withdrawal of the nipple, it is made with two laterally projecting lugs, one at each side. By driving a wedge-shaped tool between the flue sheet and the lugs the nipple can be started. Of course, this device is a temporary and not a permanent accessory in boiler repairs, and it is intended to take the place of the objectionable solid plug, where every flue leaks constantly or where the bead has been damaged.

PERSONAL.

AT THE ANNUAL BANQUET of the Bolt, Nut & Rivet Association, held at the Waldorf-Astoria, New York, Jan. 19, the president, Mr. James Lord, was presented with a very beautiful loving cup in recognition of his services to the association.

Mr. Lord is president of the American Iron & Steel Manufacturing Company, of Lebanon, Pa.

CHARLES P. PATRICK, who for the last three years has been connected with the New Jersey Boiler Company, Boonton, N. J., as genéral superintendent, is now general superintendent for the Alfred E. Norton Company, steel constructors and erectors, New York City, who are the successors of the New Jersey Boiler Company.

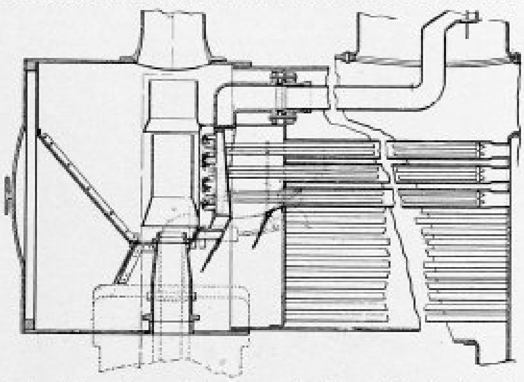
SELECTED BOILER PATENTS.

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

904,129. SUPERHEATER FOR STEAM BOILERS. ARTHUR WILMOT HORSEY AND HENRY HOGUE VAUGHAN, OF MONTREAL, QUEBEC, CANADA, ASSIGNORS TO AMERICAN LOCOMOTIVE COMPANY, A CORPORATION, OF NEW YORK.

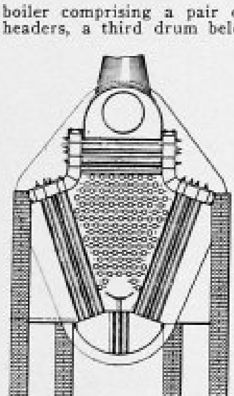
Claim 1.—A superheater comprising a saturated steam header body located above a set of superheated fire tubes and having a plurality of header branches extending downwardly between the vertical rows of said fire tubes, a superheated steam header located below the set of



superheating fire tubes and having a plurality of header branches extending upwardly and alternated in position with the saturated header branches, and a plurality of loops of superheating pipe connected at their ends to the saturated and superheated header branches, respectively. Twenty-two claims.

904,385. TUBULAR STEAM BOILER. HOWARD E. WARD, OF KANSAS CITY, MO.

Claim 1.—A steam boiler comprising a pair of headers, a pair of drums connecting the headers, a third drum below the pair of drums



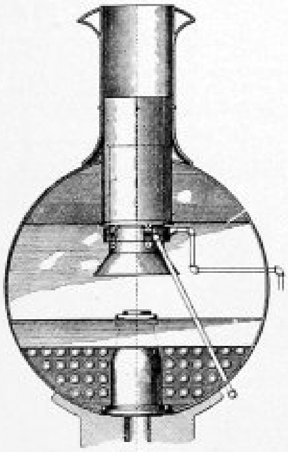
and also connecting the headers, tubes connecting said drums, and flues extending transversely through the lower drum. Five claims.

906,083. SPARK ARRESTER. OTIS N. TERRY, OF LINCOLN, NEB., ASSIGNOR OF ONE-HALF TO ROBERT D. SMITH, OF BOSTON, MASS.

Claim 5.—In combination, a smokestack and a spark arrester, comprising a square mesh wire netting aranged across the stack and provided with ordinary fence wire staples hooked over the strands and depending therefrom and having their ends bent together. Seven claims.

904,614. EXHAUST APPARATUS FOR LOCOMOTIVES. GEO. J. HATZ, OF BLOOMINGTON, ILL.

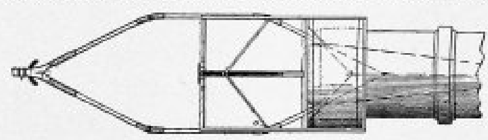
Claim.—In a device of the class described, a boiler, a cylinder, a steam connection between said boiler and cylinder, a smokestack, a hollow ring at the base of the smokestack, a transverse partition dividing said ring to form upper and lower annular chambers, the upper wall of said ring being provided with apertures leading from the upper annular chamber, nozzles extending through said upper annular chamber and communicating through apertures in said transverse partition with the



lower annular chamber, a pipe leading from the cylinder live steam port to the upper annular chamber, a pipe leading directly from the boiler to the lower annular chamber, and a valve in said last-mentioned pipe. One claim.

906,194. APPARATUS FOR BURNING FUEL IN FURNACES. EARL M. BUNCE, OF FENTON, MICH.

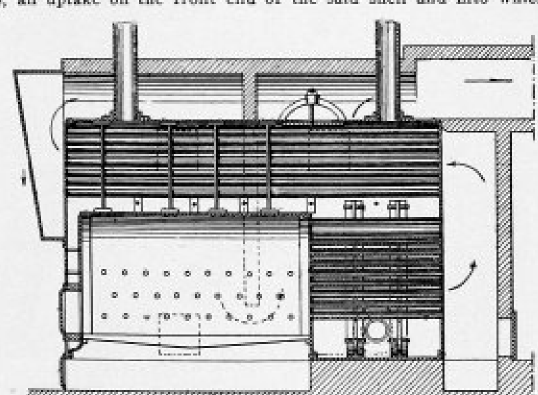
Claim 1.—The combination with a furnace, of a discharge pipe swiveled or universally jointed at its front end in the wall of the furnace and bodily movable at the rear end to positions within the arc of a



circle, and means embracing a pipe universally jointed to the rear end of the discharge pipe for delivering air and fuel to said discharge pipe. Nineteen claims.

906,269. BOILER FURNACE. JOHN O'NEILL, OF NEW YORK, N. Y.

Claim 1.—A boiler furnace, comprising a fire box, a set of smoke flues extending rearwardly from the said fire box, a combustion chamber into which discharge the said smoke flues, a set of return smoke flues above the said fire box smoke flues and extending from the said combustion chamber, a shell for the said fire box and the said sets of smoke flues and forming a water compartment having outlet and return pipes, an uptake on the front end of the said shell and into which dis-



charges the said set of return smoke flues, and a return heating chamber exterior of the sides and top of the said shell and into the front upper end of which discharges the said uptake, the said heating chamber having a transverse baffle extending from the top of the chamber to within a distance from the bottom thereof, and a duct leading from the rear upper end of the said chamber for carrying off the smoke and gases. Two claims.

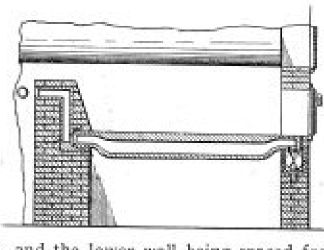
906,898. BOILER-TUBE CLEANER. ALBERT F. KRAUSE, OF BUFFALO, N. Y., ASSIGNOR OF ONE-HALF TO CHARLES C. LADD, OF BUFFALO, N. Y.

Claim 1.—In a boiler-tube cleaner, a scale-detacher, comprising a head, a shaft arranged lengthwise thereon, capable of rotary adjustment

and having an eccentric or offset portion, and a cutter or cutters mounted on the eccentric portion of the shaft. Five claims.

907,111. GRATE-BAR AND FUEL-STVER. JOHN MILLER FLEMING, OF IROQUOIS, ONT., CANADA, ASSIGNOR OF ONE-FOURTH TO HIRAM WYMAN CHAMBERLIN, AND ONE-FOURTH TO JAMES ROBERT GARDNER, OF OTTAWA, CANADA.

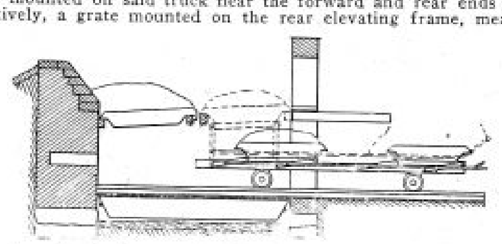
Claim 2.—In an apparatus, a hollow grate bar, whose upper surface is substantially in a straight line, the walls of the upper portion intermediate ends being thicker than the walls of the lower portion and the



walls at each end, and the lower wall being spaced from the upper wall, intermediate its ends a greater distance than the space between the upper and lower walls at each end, whereby an enlarged chamber provided with a restricted inlet and a restricted outlet is formed. Five claims.

906,336. DEVICE FOR FIRING LOCOMOTIVES. WILLIAM ALLEN TETLOW, OF SALEM, OHIO.

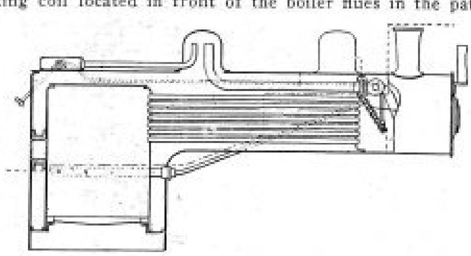
Claim 1.—In a furnace, a bridge wall, a track projecting from the bridge wall beyond the front wall of the furnace, a stationary grate, and a removable grate in said furnace, and a hinged bar supporting one end of said removable grate, combined with a truck mounted to travel in and out of said furnace on said track, a pair of elevating frames mounted on said truck near the forward and rear ends thereof, respectively, a grate mounted on the rear elevating frame, means pro-



jecting beyond the front wall of the furnace and connected to the forward frame for elevating the latter to engage the same with said removable grate in the furnace to remove said grate from its supports on to the said forward frame of the truck, and supporting means also projecting beyond the front wall of the furnace and connected to the rear frame on the truck for elevating the said frame to place the grate carried thereby in the position vacated by said removable grate. Two claims.

906,341. FURNACE CONSTRUCTION. WILLIAM A. WALKER, SR., OF ALLEGHENY, PA., ASSIGNOR OF SEVEN-SIXTEENTHS TO FRANK JOHNSTON, OF BEN AVON, PA.

Claim 1.—In a locomotive boiler provided with a steam drum, the combination with the fire box having fuel-supporting grates and outer and inner shells, of headers provided with jets extending inwardly through the inner fire box wall into the fire chamber above the grates, a superheating coil located in front of the boiler flues in the path of the



gases of combustion of the furnace having distributing pipes connected at each side of the fire box with said headers, a steam box located above the outer shell of the fire box chamber, a pipe leading from the interior of the steam drum to said box, and a pipe leading from said box along the boiler shell to the superheating coil provided with a controlling valve and an operating device therefor. Three claims.

906,423. SMOKE CONDENSER. BRICK P. HOCKMAN, OF BURBANK, UTAH, ASSIGNOR OF ONE-HALF TO ARTHUR BREWSTER, OF BLACKROCK, UTAH.

Claim 5.—In a smoke-separating apparatus, the combination of a vertically-extending stack, means for delivering fire gases into the bottom thereof, a ported partition fitted in the stack, and through which the fire gases pass, a rotary ported member disposed under and in contact with the partition, a shaft extending outside of the stack and connected with the said member for rotating the latter, and valves arranged to close the ports to hold water in the stack above the partition. Eleven claims.

906,521. GRATE. FERDINAND FRECHETTE, OF NOTRE DAME DE CHARNY, QUEBEC, CANADA.

Claim.—In a grate, a plurality of grate bars each provided with a longitudinal conduit, supports upon which the opposite ends of each grate bar are adapted to be mounted, wells in said supports, passages in said grate bars communicating with the aforesaid conduits therein and with said wells, passages in the supports connecting said wells in pairs, means for delivering water to and from said supports, and a valve in one well of each pair of wells adapted to control the flow of water through each well of the pair, the valves in the two supports alternating with one another in such manner that the valve of one support will lie beneath the end of one grate bar while the valve of the opposite support will lie beneath the opposite end of the next adjacent grate bar. One claim.

906,641. GRATE. ELI L. LONG, OF CHEEKTOWAGA, N. Y.

Claim 4.—The combination with a grate composed of bars having oppositely-extending grate faces, of a shifting rod for said bars, a swinging arm which is connected to said rod, means for moving said swinging arm to shift said grate bars, and a latch pivoted to swing at right angles to the plane of movement of said swinging arm, and having adjustable stops on its opposite sides adapted to be engaged by said swinging arm whereby the latter is locked against return movement in either of two positions. Four claims.

906,652. BOILER CLEANER. WILLIAM D. NICHOLSON AND WILLIAM H. SMITH, OF CLYMERS, IND.

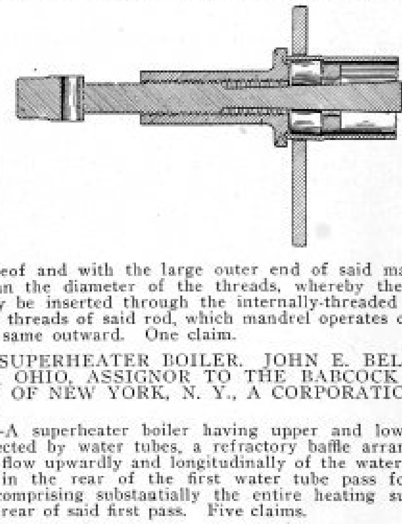
Claim.—In a device, the combination with a boiler, of a steam supply pipe connected to the source of steam supply therefrom, a discharge nozzle connected to the blow-out hole of the boiler, a plurality of disconnected nozzles arranged in alinement between the supply pipe and the discharge pipe, an inverted V-shaped shield covering said nozzles and separated therefrom, clamping devices carried by said shield for supporting said nozzles in alinement, and a plurality of legs secured on the under side of the shield for raising the shield and supporting the device within the boiler, said legs having their inner ends engaged with the nozzles so as to be held in position thereby. One claim.

906,737. UPDRAFT FURNACE. OREL D. ORVIS, OF JERSEY CITY, N. J., ASSIGNOR TO ORVIS SMOKE CONTROLLER COMPANY, OF NEW YORK, N. Y.

Claim 1.—In a furnace, the combination of a boiler, a fire box, a transverse fire brick wall at the rear of said fire box, a transverse arch located within the said fire box and above the level of the normal fuel line, and spaced from the front of the boiler and the aforesaid rear fire brick wall, whereby passages are formed for the heated gases at the front and rear of said arch, a row of bricks supported in the front wall of said furnace, in the front and rear of said arch, and in the front of the said transverse fire brick wall, the said four rows of bricks having pockets formed therein and other rows of bricks superimposed over the first-mentioned four rows of bricks and covering the aforesaid pockets, and jets for injecting hot air under steam pressure into the aforesaid pockets. Two claims.

905,846. FLUE EXPANDER. FREDERICK CLARK, OF MINNEAPOLIS, MINN.

Claim.—In a flue expander, the combination with an internally-threaded sleeve and a plurality of rollers carried thereby and movable radially therein, of a threaded rod with a mandrel tapered toward the



threads thereof and with the large outer end of said mandrel of less diameter than the diameter of the threads, whereby the said tapered mandrel may be inserted through the internally-threaded sleeve in advance of the threads of said rod, which mandrel operates on said rollers to force the same outward. One claim.

907,118. SUPERHEATER BOILER. JOHN E. BELL, OF BARBERTOWN, OHIO, ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

Claim 1.—A superheater boiler having upper and lower transverse drums connected by water tubes, a refractory baffle arranged to cause the gases to flow upwardly and longitudinally of the water tubes, and a superheater in the rear of the first water tube pass formed by the baffle, and comprising substantially the entire heating surface of the boiler in the rear of said first pass. Five claims.

907,280. PROTECTING ENVELOP FOR FURNACES. FRANCOIS PIN, OF GARENNES-COLOMBES, FRANCE.

Claim 4.—A boiler comprising in combination, a flue, an envelop or baffle surrounding the upper portion of said flue and spaced apart therefrom to form an intervening chamber, said envelop having a plurality of upwardly-projecting nozzles, a cap surrounding each nozzle and spaced apart therefrom to form a passage for steam and water, said caps having their lower margins extending below the upper margins of said nozzles, and siphon means for said cap. Seven claims.

907,841. CONSTRUCTION OF STEAM BOILERS. ARTHUR W. METCALFE AND JOHN STEEL DIXON SHANKS, OF BELFAST, IRELAND.

Claim 1.—In a steam boiler the combination with a unit comprising a plurality of tubes of a dished coupling plate at each end to which the tubes are secured, a loose coupling ring by which the coupling plate is drawn into position, and a soft metallic ring compressed between the two. Two claims.

907,987. FLUE CUTTER. LEONARD J. GEHL, OF ST. PAUL, MINN.

Claim 2.—In a flue cutter, the combination with a sleeve, of a tapered mandrel working therein and having a threaded stem provided with a nut outside of said sleeve, a spring reacting against said sleeve and against said mandrel, a multiplicity of bearing blocks subject to said mandrel and seated in said sleeve, cutting wheels journaled in said bearing blocks, and pointed retaining screws carried by said sleeve and engaging radial slots in said bearing blocks for limiting the outward radial movements of the latter. Two claims.

The Boiler Maker

MARCH, 1909

IMPROVED SHOP TOOLS.

BY D. P. KELLOGG.

Pneumatic tools long ago proved their effectiveness for doing stay-bolt and rivet work, but every boiler maker knows that there is a vast amount of hard work involved in operating a long-stroke pneumatic hammer day after day. At the Los Angeles shop of the Southern Pacific Railway a number of devices have been made which tend to eliminate this hard work, and also to obtain better results with the pneumatic tools themselves.

In driving stay-bolts by hand, 500 ends, or 400 inside and 600 outside, are considered a fair day's work with two boiler makers and a helper, whose wages would amount to $11.85 per day. By the use of the improved self-supporting stay-bolt driver, drawings of which are shown herewith, only two boiler makers are employed in driving both ends of the bolt, and it is possible to drive 1,000 bolts per day. Furthermore, this is accomplished with a saving of two boiler makers and two helpers, making a saving of $13.75 on 1,000 ends, a saving which soon pays for the first cost of the tool.

Another object which is accomplished by the use of this tool is the production of better work. With the old method of driving by hand the fiber of the iron was broken, and when it was completed the finished work under a microscope resembled the petals of a chysanthemum, whereas with the new method it is similar to driving a rivet, and the fiber of the iron is held together and upset rather than spread out and broken. The edges of the bolt are driven down securely to the sheet, so that there is no tendency for them to curl up with heating, as frequently happens in oil-burning locomotives.

This tool, in connection with another, which will be illustrated in a later issue, is also used in driving rivets, in which case it is used as a holder-on. The rivet is inserted, the pressure turned on, and when the opposite tool has driven the rivet to the sheet, and upset it, the hammer is started and given a few blows, which drives the head of the rivet up to the plate, doing very desirable work. It is also used in holding on to front flue sheets and other places where close quarters will not permit of holding on satisfactorily with other tools.

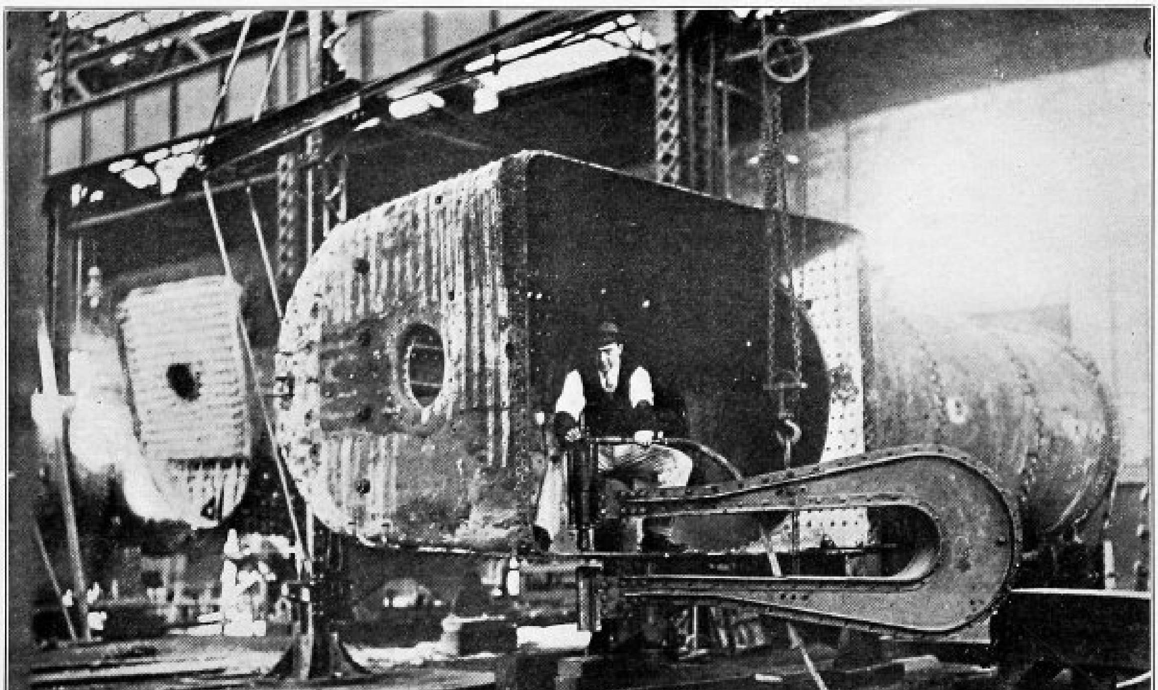


FIG. 1.—YOKE RIVETER USED FOR KNOCKING BURRS FROM STAY-BOLT HOLES.

As shown by the drawing, this stay-bolt driver uses the barrel portion of a pneumatic hammer with an adjustment containing a cylinder and a small piston, which holds the hammer against the work.

The yoke riveter shown in photographs 1 and 3 is being

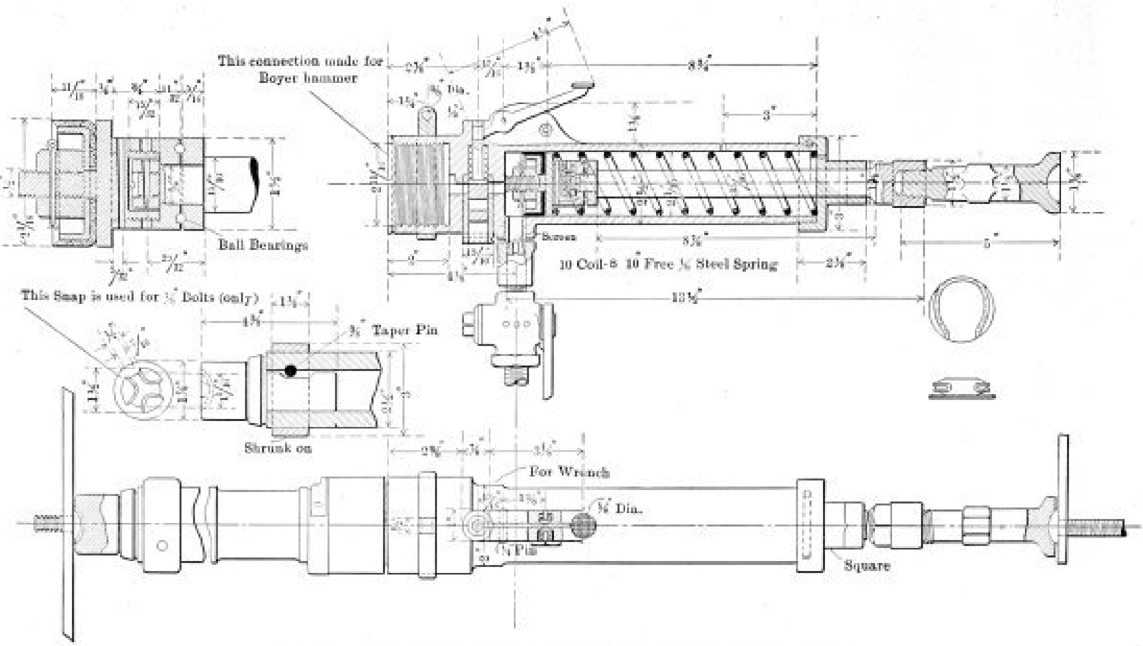


FIG. 2.—DETAILS OF SELF-SUPPORTING PNEUMATIC STAY-BOLT DRIVER.

used to knock out the burrs from stay-bolt holes in the casing sheet and fire-box after the stay-bolts have been broken and the fire-box removed. Special attention is called to the crane from which the yoke riveter is suspended. This crane has a base made of 2-inch boiler plate, 10 feet in diameter, with a heavy cast iron base attached to it. The crane itself is moved from place to place by means of an overhead electric traveling crane, which travels the entire length of the boiler shop. This crane is used not only to hold the articles illustrated, but also stay-bolt nippers or any other work for which a stationary crane would be used, as the base is large enough to sustain any weight up to the capacity of the crane without tipping. The advantage of using a portable crane of this type cannot be over-estimated, as it can always be placed in the most convenient position for the work in hand, and can always be kept busy, whereas a stationary crane is frequently idle much of the time, simply because there is no work going on near it. Patents for all these tools have been applied for.

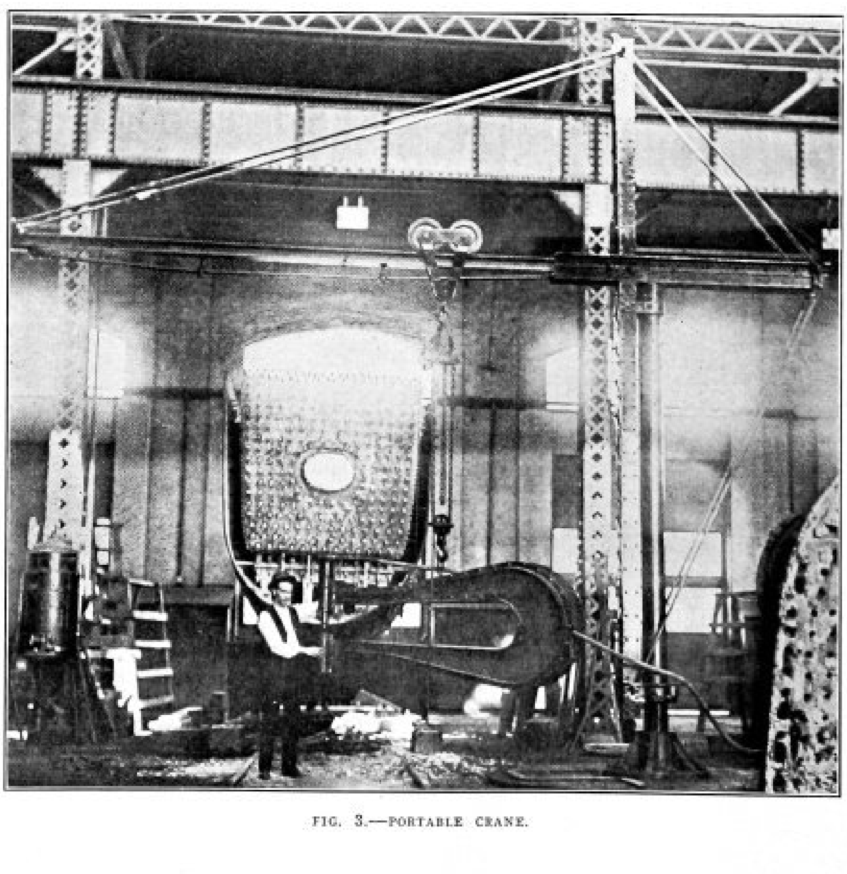


FIG. 3.—PORTABLE CRANE.

SIDE SHEETS OF WIDE FIREBOXES.*

BY C. A. SELEY.

The life of side sheets in the modern wide-firebox locomotive is a problem that is demanding the active attention of motive power officials because of their decidedly shorter life as compared with side sheets in the older narrow-firebox types. A prominent railway mechanical officer recently stated the matter about as follows: "That the old-style deep firebox with ogee† sides was rather hard on staybolts, but the boxes lasted on an average of from six to nine years. The later wide fireboxes, while easier on staybolts, frequently fail in two or three years. On this showing it was thought that the tendency in firebox design would be towards a modified ogee side with very flowing lines."

The above statement presents an effect and a possible remedy, but does not consider the causes. It is unfortunate if we cannot utilize an increase in the width of the grates to secure the area necessary in large locomotives without having such a decided reduction in the life of the side sheets. It has not been noted that the crown sheets are similarly affected, there has been no radical change in the quality of the steel employed, or of the fuel or service demanded of the locomotive, that would account for the trouble, and we are forced to the conclusion that there must be some element in the design or operation of wide fireboxes which has an unfavorable influence not clearly understood.

By the life of side sheets is meant serviceable condition, freedom from cracks, leakage, and other failures that may require renewal. The life is not particularly affected by the pressure carried, as the staying is generally done with a large factor of safety, but is directly affected by the temperature changes, the expansions and contractions, in service under steam, as well as when out of service on sidings or over cinder pits and in washing out, and water changing in the roundhouse.

Steel will stand a certain number of stresses before failure, dependent on the degree or amplitude. We can increase the number of applications of a test specimen by decreasing the amplitude. In a firebox it is difficult to decrease the number of the applications, as they are dependent on the service of the engine, the number of times it is fired up and cooled off, and these conditions are not materially different for the two types of fireboxes under discussion, and thus it may be that the short life of the side sheets of wide fireboxes can be accounted for by the greater amplitude of the movement or increased expansion and contraction.

At first thought, one would say that the ogee box presents a series of curves that will adjust themselves to meet those movements in a way not possible in the straight and more rigid side of the wide box. This is true only in part, as the side is straight longitudinally in both designs, and this is the most important direction. Apparently, therefore, the increased amplitude must be accounted for by a higher internal temperature of the side sheets by reason of less perfect heat transmission to the water in the leg.

In the later designs of boilers we find a general tendency towards the use of wider mudrings and water legs than formerly. This has resulted in giving staybolts longer life, as their increased length gives a smaller amplitude of vibration or motion, but it has also decreased the rate of the flow of the water upward proportionally as the volume of water in the leg is increased. This point will be considered later.

* Read at the December meeting of the Western Railway Club.

† The form having a reverse curve in section with the convex part above.

In getting away from the ogee form of box and the narrow water leg, it was thought that the circulation of the water would be improved, as the ogee presents a curve adverse to the direct vertical rise of the water as it is heated and displaced by the cooler water coming from the throat. The results, however, would seem to prove this theory wrong, or at least we have only gained in life of stay-bolts.

The secret of the matter seems to be that, if the rate of flow and its wiping, scrubbing, impinging action can be directed against the side sheets it has the effect of wiping off the steam bubbles as they form, prevents their combining into a film or curtain of steam against the sheet, which is by no means as good a conductor of heat as is the solid water. This theory will account for increased internal temperature of vertical and inwardly-inclined side sheets, and can be inferentially proven.

It is well known that crown sheets outlast several sets of side sheets, and while this is due in part to the fact that there are not the same variations of temperature at the same time in different parts of the sheet, it is also true that its surface presents no chance for formation of a film of steam, and it has practically solid water in contact with it at all times.

This is also true of the Wooten type of furnace, the parts failing being generally a limited portion at the sides, which approach the vertical. It has also been noted that the door sheets of fire-boxes which have moderately inclined back heads do not last as long as those that are vertical. The incline forces the wiping action of the circulation against the outer sheet.

It has been stated that in the early days of torpedo boat design, a locomotive type of boiler was tried because of its great efficiency and amount of steam produced per foot of heating surface in locomotive service. On the boat, however, it was an utter failure. By way of experiment this boiler was put on a vibrating cradle, which greatly increased the steam production. This could only be accounted for by an increased circulation, facilitating the heat transmission. It has been proven by late government experiments that increased boiler efficiency can be obtained by increasing the rate of flow of the gases, this action tending to wipe off from the heating surface the partially cooled gases, replacing them with new and hotter gases.

Thus the question of circulation, whether of water or gases, seems to be a very important factor in boiler efficiency, and while some of the examples quoted may be somewhat remote in their application, yet they seem to point to the circulation in the water leg as being a vital factor in the life of side sheets.

There seems to be no question that if there is a strong impinging circulation against the fire sheet, the heat will be more freely transmitted, steam film prevented, solid water maintained against the sheet, and the internal temperature of the sheet kept down and the amplitude of the sheet movement reduced to the minimum. To effect this the side sheets should not be vertical nor sloped inward, but be sloped or curved outward from above the fire line, but it is obvious that this cannot be extreme without getting into grate area difficulty.

It is quite possible, however, that we have gone too far and are too liberal in that respect, as the reports of successful steaming of some recent engines would seem to indicate, these engines having a much lower proportion of grate area than is at present common. If a reduction of grate area can be made, it will permit the modification of side sheets as proposed.

The question might also be raised as to the width of water leg. Aside from affording sufficient room to hold the accumulated sediment to a safe height, there seems to be no good reason for a wide leg except from the stay-bolt point of view. There is no question of a stronger circulation with the narrow leg, and, if need be, some form of flexible stay-bolt could be considered for extreme cases of angular movement.

In the older designs of fire-boxes it was often 80 inches from the mud-ring to the water level above the crown sheet, the water varying in temperature, while in circulation, from 150 to 180 degrees at the bottom to the temperature due to the steam pressure at the top. The depth of this column of water in wide fire-box designs is very materially decreased, and as the temperature limits are about the same, it is apparent that for an equal width of water space the rate of flow of the circulation as a whole would be decreased about proportionately to the travel. If, in addition to this, the width of the water leg be increased, the rate of movement is further decreased.

If rapid circulation and a wiping effect will serve to carry off the steam bubbles, preventing steam film and overheating of fire sheets, this function has been absolutely sacrificed in many wide fire-box designs and the short-lived side sheets seem to prove it. The highest duty boilers are those having the most rapid circulation. The water spaces in legs and between tubes of fire-engine boilers are very small, but the probabilities are that the rate of steaming and efficiency would be decreased if these spaces were materially increased and the larger volume of water would lower the rate of circulation.

It is quite likely that the rate of movement in the locomotive water leg has much to do with this question. The water next to the fire sheet has an upward tendency. That next to the outside sheet can only rise when heated by conduction through a body of water equal to the entire width of the leg, or by the mingling, mixing action set up when the sheets are not vertical. There seems to be a reasonable ground for the belief that there is a very sluggish circulation in a directly vertical water leg of considerable width, contributing to formation of a steam film and overheating of the sheets when fires are forced.

This discussion would not be complete without considering the other end of the temperature scale to which the fire sheets are subjected. As before stated, it is the amplitude of the vibrations or movement of the sheet which are most subject to control. All possible mileage should be made between knocking out of fires. Firing methods can often be improved so that an engine can be returned without knocking the fire. The usual ash-pit methods use up much of the life of side sheets, and cold-water washing and filling and rapid firing up takes a lot more. It is quite true that the old-time fire-boxes had to stand all this, but while considering temperatures and their effects it would be just as well to help on the lower end of the scale if possible.

Improved methods of blowing down and filling up of the boiler at terminals, hot-water changing and washout plants are now well demonstrated, and these will all help to reduce the amplitude of the temperature scale traversed in locomotive operation as regards the fire-box sheets and thus add to their life.

In closing the discussion the writer said: "I think I have attained my object in getting a discussion on this rather interesting question. The idea that I had in mind was simply to find some reason why the modern wide fire-boxes are lasting one-third of the life of the old-time boxes. In seeking for a theory it occurred to me to consider those elements which contribute to ultimate failure, viz.: the vibrations or the expansions and contractions or movements of the sheet in the performance of its duty. I do not know that I am right yet, but at the same time if there is successful performance of fire-boxes about 60 inches wide, and boxes wider than that have not given as good performance, it would indicate that the slope of the sheet, due to the narrower width, had something to do with it. Now, just how that works out; whether I am correct in supposing that that upward circulation against an outwardly-inclined sheet assists in wiping off the steam bubbles and combining them with the current, transmitting the heat, warming up the entire body of water in the water leg, instead of permitting a curtain or film of steam which will contribute to the overheating of the sheet, it at least seems to be a reasonable theory or explanation with some foundation for it.

"Whether Mr. Fry's theory of downward circulation or mine of facilitating wiping action of the circulation is used, the result is the same as regards the desirability of outward instead of inward inclination of fire-box side sheets.

"As regards Mr. Squire's inquiry about the solid water, it would seem to me that there is absolutely no possibility of a steam bubble combining with another and another and another until there is a film on any portion of the crown sheet which is considerably beyond the vertical. If the volume of the water leg is increased by greater width of water leg, I think it is reasonably sure that the rate of the circulation as a whole is decreased, due to that larger volume, and if the rate of circulation is a factor in keeping down the internal temperature of the sheet, the failures are in accord with my theory.

"What I am trying to find out is this—you will probably all admit that a fire-box sheet has a certain life, it will stand so many vibrations, so many expansions, so many contractions, from the normal and then it will develop that crack that goes off like a pistol shot, or some other way; at any rate there is a failure of the sheet. Now, that being the case, if we can lengthen out the period of time over which that total movement will happen, we get the increased life in our sheet. It seems to me that if the box is designed in such a way that the internal temperature of the sheet is kept down by keeping solid water against it by any means whatsoever, then with all of the fire-boxes, even with the despised ogee, we have made a distinct gain. I think this is a matter worth thinking about, and possibly of going into our records of fire-box failures. Classify the fire-boxes of different widths and angles and forms on our roads, and go back through our records for years, and find out the number of fire-boxes and side sheets that have been applied, and see what results we obtain. I do not believe that it is due to the quality of fire-box steel falling down necessarily, but probably a matter of design.

"As regards Mr. Wickhorst's belief that there is no downward circulation, or at least that there does not seem to be much to support that theory, I agree with that in a great measure. My idea of the circulation is that it is very rapid, upward, against the inside sheet and less rapid at the outside, so that a number of inclined lines, each of a greater angle, would express the velocity as I understand it. But I can hardly understand why water up at two-thirds of the height of the fire-box against the outside sheet should come down. I cannot see why it will not rise, although at a very less rate than that of water that is close to the fire-box sheet.

Rapid Plate Punching.

At the structural shops of the receivers of Milliken Bros., Inc., on Staten Island, New York, 143 tons of plate were punched in 8 hours 47 minutes in one machine tool. The plates were 13-inch flanged plates for girders 5/8 and 11/16 inch thick, averaging about 32 feet in length. The average number of 15/16-inch holes was about 96 to each plate, staggered except at the ends.

There were three sizes of plates and varieties of spacing—52 of one kind, 168 of the second and 96 of the third. The total length of plate handled was 10,036 feet; weight, 285,850 pounds, and the total number of holes punched 30,384. This work was done on a multiple punch, four plates being passed through at a time.

STRESSES ON CYLINDRICAL SHELLS.

BY H. S. JEFFREY.

It is no uncommon occurrence to go into boiler shops and see riveted seams improperly designed. Indeed, it well substantiates the fact that many foremen, layers-out and designers do not thoroughly understand how to deal with this important problem. I recall an instance where a foreman made a circumferential seam double chain riveted, the pitch of rivet holes being 2 inches (¾-inch rivets). His longitudinal seam was single riveted with about the same pitch as the circumferential seam. I stood with amazement when I saw his layout of joints. With an air of general satisfaction he stated that he would fix those heads so that they would not blow out. This man was honest in his belief, but little did he know that he had the cart before the horse.

A cylindrical shell subjected to internal pressure has two forces tending to rupture it. One force tends to rupture it in the direction of its length, or in what we will term the longitudinal plane. The other force tends to rupture it at right angles to its length or in what we will term the transverse plane. Since the intensity of the force, due to the internal pressure, is equal on every square inch of surface exposed to the pressure, it is evident that the force on the longitudinal plane is equal to the area of this plane (the length of the boiler times the diameter) times the intensity of the internal pressure, and that this force is resisted by the thickness of material on both sides of the shell. As an example, I will take a boiler 60 inches inside diameter, shell plate ½ inch thick, 60,000 pounds tensile strength, length of shell 100 inches. The question now arises, what will be the total pressure on the shell plate if the boiler is to carry 100 pounds pressure? The length is 100 inches, the inside diameter is 60 inches and pressure 100 pounds, so we have 100 × 60 × 100 = 600,000 pounds total pressure on the longitudinal plane. What resistance do we have to withstand this great pressure? There are two sections of shell plate (one on each side), 100 inches long by ½ inch thick, of 60.000 pounds tensile strength. Then we have 100 × .5 × 2 × 60,000 = 6.000,000 pounds resistance.

From the above we find that we have a shell capable of resisting a stress of 6,000,000 pounds, which is loaded with only 600,000 pounds, thus the shell is ten times as strong as necessary, that is, it has a factor of safety of 10. This is on the assumption, however, that the shell is seamless, so we must look a bit further and see how the longitudinal seam affects the factor of safety. The efficiency of a riveted joint is the ratio of the strength of the joint to the strength of a similar section of solid plate.

The efficiency of the plate is merely the ratio of the solid plate to the plate left between the holes after punching. If the rivet holes are stepped off 4 inches between centers the 4 inches would represent 100 percent, and then if we punched 1-inch rivet holes we would punch away one-quarter of 100 percent, or 25 percent. Therefore, we would have left 75 percent of the solid plate. We can get this result in another way. A 4-inch pitch of rivets with ½-inch plate would make 2 square inches of area. If we punch a 1-inch hole, the area punched out would be 1 × ½ = ½ square inch. Thus ½ square inch is one-quarter of 2 square inches, or 25 percent.

When figuring the strength of rivets, it must be borne in mind that rivets in single shear do not have as great a resistance as in tension. From tests made by the M. S. B. M. A., 45,000 pounds per square inch was found to be the value of steel rivets in single shear. This creates a ratio between tensile strength of plate and shearing strength of rivet of 4 to 3, unless the rivet is in double shear, when the ratio is 15 to 22.

If our longitudinal seam is found as above to have only 75 percent efficiency, then the factor of safety of 10 is correspondingly reduced. Thus ten times the efficiency of the longitudinal seams equals the actual factor of safety, or with an efficiency of 75 percent the factor would be 10 × .75 = 7.5. This may be more readily computed by the following formula: If

T = Thickness of shell plate in inches.
TS = Tensile strength of plate.
D = Inside diameter of boiler.
F = Factor of safety.
E = Efficiency of joint.
B = Safe working pressure.

Then

$$\frac{TS \times 2T \times E}{D \times F} = B$$

Using 7.5 as the value for F and .75 as the value of E, we find the working pressure in the above problem as follows:

$$\frac{60{,}000 \times 2 \times .5 \times .75}{60 \times 7.5} = 100 \text{ pounds pressure.}$$

It might be well to state here that even the United States marine laws do not consider the efficiency of the longitudinal seam, but allow a pressure that has only an actual factor of safety of from 3 to 3½. Their rule is to multiply one-sixth of the tensile strength by the thickness of plate and divide by one-half of the diameter, and the result will be the allowable working pressure for a single riveted joint, all holes fairly drilled. Add 20 percent for double riveted joints. They do not specify what kind of joint, whether lap or butt. Assuming a double riveted joint on the boiler under consideration we find that they would allow a working pressure as follows:

$$60{,}000 \div 6 = 10{,}000 \text{ pounds, } 60 \div 2 = 30 \text{ inches.}$$

$$\frac{10{,}000 \times .5}{30} = 166\ 2/3 \text{ pounds.}$$

20 percent of 166 2/3 = 33 1/3, 166 2/3 + 33 1/3 = 200 pounds working pressure. We found, figuring with the same efficiency, that our factor of 7.5 gave 100 pounds. The United States rule gives 200 pounds, so this shows that they have only a factor of 3¾. As they pay no attention to the efficiency, a riveted joint having 68 percent efficiency would be allowed the same pressure as one of 75 percent efficiency.

We will now take up the stress on the transverse plane and try to throw some light on the reason for single riveted girth seams. We will use in our calculations the same boiler, which is 60 inches inside diameter, ½-inch plate, which gives 61 inches outside diameter. To find the pressure that is exerted on the head we have

$$60 \times 60 \times .7854 \times 100 = 282{,}743 \text{ pounds.}$$

This pressure is resisted by the sectional area of the plate contained in a cross-section of the boiler shell, which may be found by subtracting the area corresponding to the inside diameter from the area corresponding to the outside diameter. Then

$$61 \times 61 \times .7854 - 60 \times 60 \times .7854 = 94.84 \text{ square inches.}$$

What resistance has this area? Here is where we must stop and consider. If the plate is homogeneous, its resistance will be equal in all directions, but all plates are not homogeneous. Iron having a tensile strength of 48,000 with the grain, has about 42,000 across the plate, giving a ratio of 8 to 7. Steel, however, is more homogeneous than iron, and this ratio is not so large, running about 15 to 14.

As the stress will not be with the fiber, the tensile resistance of 60,000 pounds will be reduced by the ratio of 15 to 14, giving a tensile resistance of 56,000 pounds per square inch for the transverse stress. (Note: Butt straps should always be cut across the fiber.) Steel plates that are homogeneous have the same resistance in the transverse plane as in the longitudinal plane.

Thus, $94.84 \times 56{,}000 = 5{,}311{,}040$ pounds resistance and $5{,}311{,}040 \div 282{,}743 = 18.78$ factor of safety. This factor of safety is based upon solid plate, but as the girth seam is to be single riveted we will assume the efficiency to be 55 percent. Thus, $.55 \times 18.78 = 10.32$ actual factor of safety. If the efficiency of the girth seam is increased or the plate is homogeneous the factor will increase. Girth seams in the majority of boilers do not get the full transverse load as braces, flues, stays, etc., in many cases materially assist the shell plate.

FASTENING TO CONCRETE FOUNDATIONS.

The other day I saw a workman with a cold chisel and hammer trying to make a hole in a concrete base which had been made to support the legs of a small boiler. There were other tools strewn about. A boy was there with a water can and an oil can. While the man chipped and gouged and swore, the lad poured either water or oil on the brittle stuff, in hopes of softening it more or less. But the chipping and hacking failed to amount to much. The man succeeded in destroying the edge of his tools, and that was about all. In another shop I noticed that, under similar conditions, the workmen endeavored to make holes in the concrete boiler base with boring tools. If you can rig up something so as

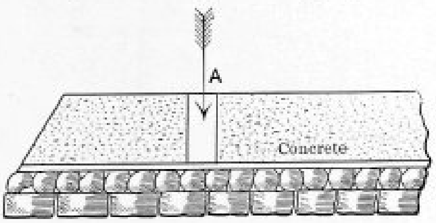


Fig.1

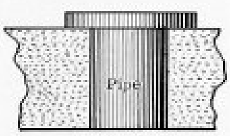


Fig.2

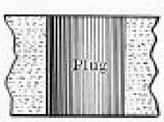


Fig.3

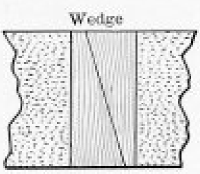


Fig.4

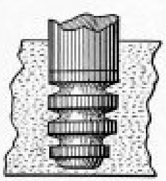


Fig.5

DETAILS OF CONCRETE BOILER FOUNDATION.

to get a hard, steady pressure on the brace or the boring-tool frame, then, if you can give the necessary revolutions to the boring tools, you may and you may not be able to penetrate the tough material with the point. It is quite a proposition to get fastening devices joined to cement compositions once the material is hardening; therefore the suggestions given in this article relative to the preliminary preparation of these bores may be of service to men who have struggled with concrete foundations and slabs with the idea of putting the fastening bolt and lag screw holes in after the slab is in position.

Assume that the concrete foundation is made in the ordinary manner, with the proper stone, pile, sand or gravel base as in Fig. 1. The concrete is made of the usual mixture of Portland cement, sand, gravel and water. If you get at the concrete while it is still soft, you will have no trouble in making the hole or holes needed. The trouble is, that the concrete is usually made before you know where the holes are needed, or perhaps the entire slab is turned out at some

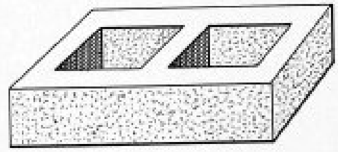


Fig.6

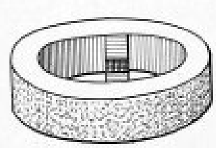


Fig.7

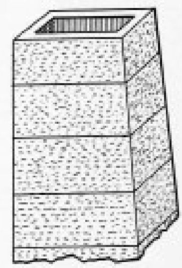


Fig.8

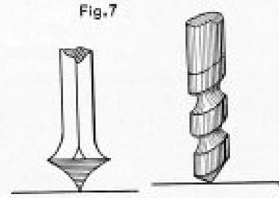


Fig.9

SECTIONS OF CONCRETE CHIMNEY.

other place and moved to the spot needed, like any other part of the plant. You will need a number of holes like *A*. If you have to bore these holes for the bolts or lag screws, you will have numerous complications and many delays. If you can punch the holes while the concrete is still soft, you gain a point; but the best way of all is that adopted by some of the concrete-base makers, who introduce plugs, pipes, pins, rods, etc., as molds for the desired holes. In one shop they were making the holes by using a number of pieces of flanged gas pipes, as in Fig. 2. The flange affords means for lifting the form when the concrete is dry. Sometimes a common, hardwood plug is used as in Fig. 3, in which case trouble is usually experienced in removing the plug without cutting it. Therefore wedge plugs like that in Fig. 4 are recommended.

Then, again, there are demands for threaded bores in concrete foundations. The threaded bore is made by using a form made with a heavy thread cut on it as in Fig. 5. When the concrete is dry, the threaded spindle is simply turned out. Then the threads remain cast in the concrete and are in readiness for the threads of the bolt to be inserted permanently for fastening purposes.

Sometimes the hollow blocks for chimneys for boiler plants are cast on the same plan. One of the blocks with double openings is shown in Fig. 6. The separate blocks are adjusted one above the other in the formation of a stack. In case the stack is high, the upper blocks decrease in size, so as to form the required taper from the bottom to the top of the stack.

In the event of a round stack, the blocks are cast circular, as in Fig. 7. Fig. 8 shows the arrangement of placing one block upon the other in shaping the chimney. Dovetailing and similar processes are used for making the necessary fastening connections between the individual blocks. These fastening contrivances, aided by cement, serve to make the joints tight and lasting.

As to penetrating cement blocks with boring tools, I have used the fan-form of point and also the common drill, as in Fig. 9, with success. OBSERVER.

INCRUSTATION AND CORROSION.

Causes and Prevention in Steam Boilers and Pressure Vessels of the Varied Industries.

BY R. E. M'NAMARA.

There are probably but few problems in the engineering profession or mechanical trades which are of more vital interest to those directly concerned than the elimination of the deteriorating influence of corrosive elements, scale, acids and alkali, as observed in our study of pressure vessels, consisting of boilers, digesters, bleachers, dryers, converters, rotaries, rendering tanks, etc., of the varied industries. It has been estimated that more millions of treasure could be made by an elimination of this depreciation than can be extracted from all the known gold mines of the world. As probably 80 percent of the pressure vessels in use are steam boilers, the remedial methods applicable to them will be taken first. When we consider the number of them in use and the varying local

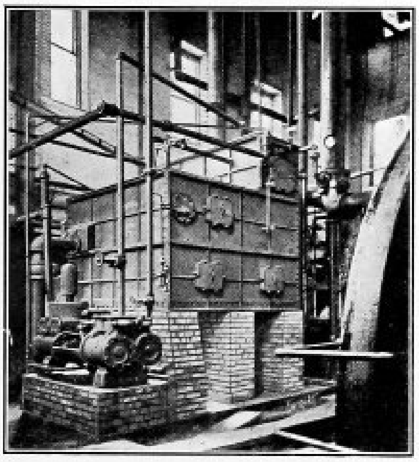


FIG. 1.

conditions throughout the country, it will be readily understood that no specific methods of procedure will apply in all cases; therefore, to form a standard of comparison the principal corrosive elements and scale-forming compounds found in most waters will be treated in order. These are as follows:

Sulphuric acid, or oil of vitriol; carbonate of lime, or limestone; sulphate of lime, or plaster of paris; chloride of sodium, or salt; chloride of magnesium, bicarbonates of iron, magnesia and lime. Carbonate and sulphate of soda, oxide of metals, silica, oleic, stearic and palmetic acid, soluble salts, earthy and organic matter and sewage.

Those of the above which come under the head of acids are often counteracted by the use of an alkali, except in breweries, packinghouse tanks or wherever foreign chemicals will spoil the products. Alkalies are chemically known as the opposites of acids. Potash, soda and ammonia are representative examples. Water, as found distributed over the earth's surface, is never free from impurities, as it is one of the greatest solvents known, absorbing varying proportions of whatever element or compound it comes in contact with. A chemical analysis is therefore always necessary to determine its impurities and the corresponding chemical reagent required to counteract them. Water analyses are of two kinds—qualitative and quantitative. The former can be made by most anyone, after having procured a few chemicals, as named and outlined in the following pages. A qualitative analysis, however, does not show the exact proportion of any ingredient, it merely indicates its presence. A quantitative analysis gives the kind of impurities present, also the amount of each, and as it generally takes an expert chemist with a complete laboratory to make one, a description of the process will be deferred until the final chapter of this serial.

QUALITATIVE ANALYSIS.

To test for corrosive acids: (1) dip a strip of blue litmus paper into a sample of the water; if the paper turns red, the water is acid and hence corrosive.

(2) A still more delicate method is to add one portion of methyl orange to twenty of water in a clean, glass vessel; if

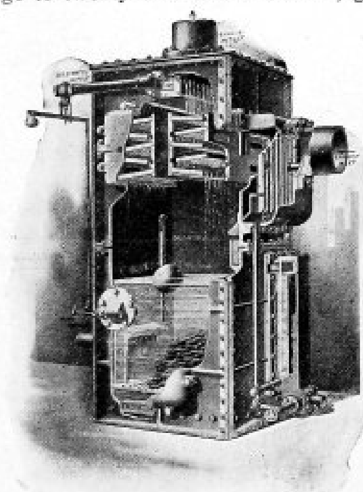


FIG. 2.

the mixture turns pink the sample is acid, if the color remains yellow it is alkaline and harmless to most metals except brass and copper. To test for carbonate of lime, which is the same thing as limestone, half fill a glass crucible with the sample, to which add a small portion of ammonia and ammoniam oxalate, and heat to boiling point; if a precipitate is formed it indicates the presence of carbonate of lime.

To test for sulphate of lime, which is the same thing as plaster of paris, half fill a glass with the water to be tested, to which add a few drops each of barium chloride and hydrochloric acid, and heat gradually to 212 degrees F., until enough has evaporated to form a noticeable precipitate; if a solution of nitric acid will not redissolve the sediment, the experiment indicates the presence of sulphate of lime.

To test for organic matter, nearly fill a glass jar with the feed water, to which add a few drops of oil of vitriol and enough potassium permanganate to render the solution rose-colored; stir the mixture and allow it to settle from five to ten hours; if the color is found to have changed over a shade, then organic matter is present.

Matter or sediment in mechanical suspension only may be determined by allowing a sample to settle, or filtering through a Gooch crucible. In boiler feed water, carbonates and sulphates of lime are, in general, most frequently met with, the carbonate forming a white, medium soft, flowery scale, deposited in conjunction with the sulphate of lime; however, it is often hard and not easily removable. Fortunately, neither in themselves are corrosive elements. The carbonates of lime may, for the most part, be eliminated from the feed water before entering the boiler by several methods, two of which involve the use of chemical reagents, and one by heating. A process devised by Dr. Clark, and known in Europe as the Clark process, consists of treating the water with slaked quicklime, adding 28 grains of lime to each 50 grains of carbonate in the water. After settlement and filtration, the water is quite free from carbonate of lime, and is also clear and transparent, as may be observed in the settling tanks of municipal water-works systems in various cities where this process is used.

Caustic soda is also extensively used, 8 grains of soda to 10 of carbonate of lime being the proportionate mixture. In a boiler plant, however, where marked economy is obtained by heating the feed water, advantage is taken of the fact that the carbonic acid gas is liberated at from 210 degrees to 212 degrees, thus allowing the carbonates of lime to be precipitated. This action usually takes place in the heater, using exhaust steam from the engine. In an engine exhausting without back pressure, however, the temperature of the exhaust steam can never be above 212 degrees, although it still contains a large percentage of its heat, before the available portion is extracted in the heater, the temperature of the contained water may not have reached over 150 or 200 degrees. In such cases, of course, the carbonate of lime is not precipitated but goes through the heater into the boiler. Ordinarily, however, with a good, open heater the temperature of 210 degrees is often obtained, thus liberating most of the carbonic acid gas and throwing down the carbonate precipitate.

It frequently occurs that sulphate of lime is also present in the feed water in conjunction with the carbonates. Sulphate of lime, however, does not precipitate in the solid form until a temperature of about 290 degrees F. is reached, corresponding to a boiler pressure of about 45 pounds. Therefore, in an open heater, relying upon temperature alone, the sulphate would of necessity be carried through the heater and into the boiler, and remain in suspension until the critical temperature is reached. By treatment with soda ash (Na_2CO_3), however, in a combined heater, purifier and filter, of which Fig. 1 is a representative type of the open class, most of the sulphate, as well as the carbonates, will be thrown down and separated by settlement and filtration in the settling chamber shown in sectional view, Fig. 2.

While open heaters are generally cheapest in first cost, and are principally installed in the smaller plants, it is not always desirable to use them for various reasons; one of which is: when exhaust steam mingles with the feed water, a portion of the cylinder oils present are fed into the boiler. In the days of low pressure, cylinder oils were mainly vegetable and of a low flash point; with the advent of high-pressure engines and boilers, vegetable oils were found to carbonize, due to the extra heat, hence mineral oils of a higher flash point were substituted. Unfortunately, however, under the influence of heat and steam, mineral oils have a tendency to decompose into corrosive acids, known, respectively, as oleic, stearic and palmetic acids. When vegetable oils were carried over from the heater into the boiler it was customary to boil out the vessel with soda or potash, thus saponifying the deposit; or, in other words, converting it into soap, which was easily washed out. Mineral oils, however, do not saponify with the ordinary treatment; therefore, when condenser tubes, heaters and boiler shells become thus affected, mechanical means are generally resorted to for removal. In a closed heater or surface condenser the exhaust steam does not come into direct contact with the water, either circulating around or through tubes or coils whose opposite surfaces are exposed to the steam or water, as the case may be. A closed heater may, therefore, when live steam is used, be made to deliver water at a high enough temperature to precipitate both the carbonates and sulphates of lime, together with other common impurities, and deliver water to the boiler free from fatty acids and without the use of chemicals, hence the advantage over open heaters in this respect.

Boiler compounds having various chemical ingredients are

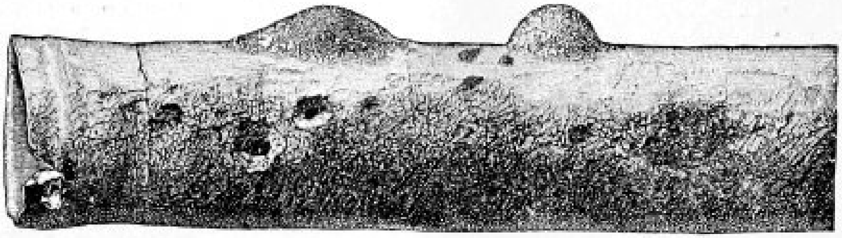


FIG. 3.

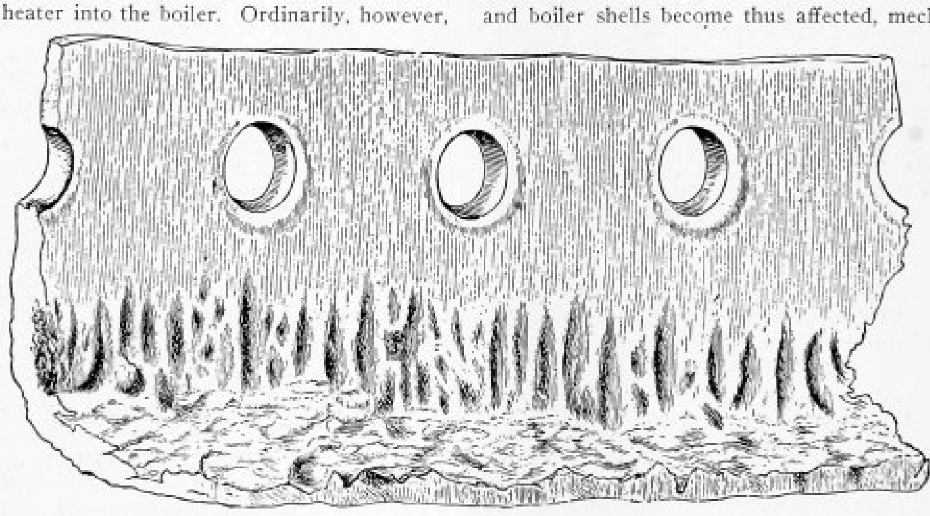


FIG. 4.

extensively used in almost every bad-water district. Strictly speaking, however, they are all wrong in principle, as in a measure they render a boiler like a chemical retort. A purification of all water, either by filtration, chemicals or heat, or a combination of the above, is the ideal practice when conditions will allow. Caustic soda, or soda ash, is the principal ingredient of most of them; some may also contain salamoniac, tannin, tri-sodium phosphate, etc., which, under exceptionally favorable conditions, may be harmful and cause corrosion. The use of compounds where their composition is suitable for the water in question, is to be recommended, although it may be said to be but a compromise between two evils.

Corrosion.

From the foregoing it would be reasonable to suppose that absolutely pure water would be the ideal boiler feed. Strange as it may seem, such, however, is not always the case, as may be verified by actual experiment, and is also very noticeable in the low-pressure heating systems of buildings where the distilled returns are used over and over, corrosion, pitting, honeycombing and grooving are common results from its use. It has often been noticed that frequently where a high and a low-pressure boiler were used in the same house and under the same conditions, after a few years' time the head, shell and tubes of the low-pressure boiler would exhibit an appearance as shown in Figs. 3 and 4 (cuts taken from *Locomotive,* June, 1896, and April, 1886), while the high-pressure boiler would not be affected by corrosion in the least. Several explanations will apply to the apparent phenomena; the two most generally accepted are (1) the action of carbonic acid gas, oxygen, heat and moisture, as found in pure distilled or condensed water at a critical temperature; (2) galvanic action. Probably a combination of both influences would satisfactorily explain most cases.

GALVANIC ACTION.

In our study of galvanic action, electrical science teaches that the earth is an infinite reservoir, charged at zero potential; every object in nature is also charged more or less with

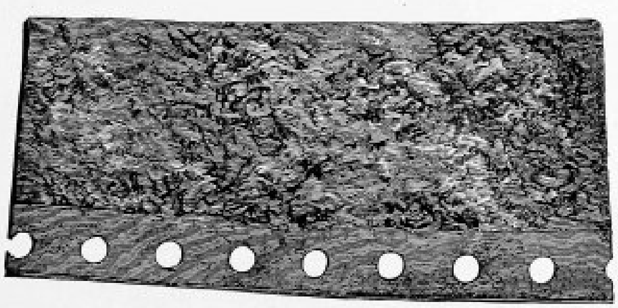


FIG. 5.

a fractional amount. When two dissimilar substances are brought into contact, one of them always assumes the positive and the other the negative condition; electricity flowing from the positive to the negative. Copper and zinc are two of the metals in which this action is most pronounced, partially submerging copper and zinc in a saline solution induces an electric current which may be measured by a galvanometer, this being the process of some batteries, and is the principle used in electro plating, one of the metals being decomposed and deposited on the cathode.

A low-pressure steam boiler may be likened to a gigantic electric cell, the shell, tubes and brass fittings constituting the electrodes, or anodes and cathodes, the distilled or concentrated water being the electrolyte; thus a current of feeble but constant potential is at work liberating hydrogen gas and slowly attacking the plate. Whole sheets, and sometimes individual tubes, are left intact, while in other portions of the boiler patches of varying area may be corroded almost entirely through. This is due partially to two causes: First, it is known that iron, even from the same mine, differs in composition; portions of the same sheet are also at times chemically quite unlike; the electrolytic action, therefore, following the law of least resistance, dissolves that portion for which it has the greatest chemical affinity. Second, in any steam boiler, however badly designed, there is bound to be some circulation. Where the sweep of the water is the greatest, chemical reaction has but little opportunity to take hold or progress, hence the apparent immunity of some of the unaffected portions. Bars of zinc suspended or slung from the girder stays theoretically have a tendency to confine the

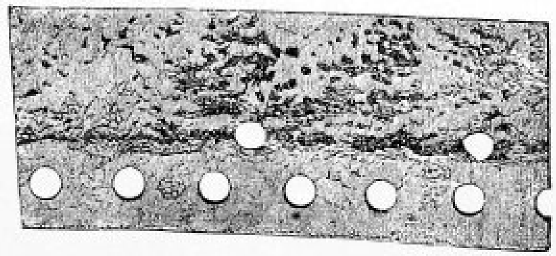


FIG. 6.

galvanic action within narrower channels; being in themselves negative electrodes, they concentrate the electric potentential to the ultimate destruction of themselves, and in time must be replaced. Zinc is also said to be beneficial for the prevention of scale, and is largely used in the boilers of seagoing vessels.

THE ACTION OF OIL.

There are great differences of opinion between eminent engineers and prominent boiler makers as to the merits or demerits of using oil in steam boilers, some condemning the practice entirely, others claiming to have achieved quite beneficial results. Much has also been said and written on the above subject by various authors. In general, however, they do not quite agree; therefore it will be beyond the scope of the writer to make positive assertions other than giving views from past observation and experience. Oils, as generally used in boilers, are mineral, and have a comparatively high flash point; they also vary from dark, crude petroleum to white kerosene. Kerosene is one of the first products of the petroleum; still, it contains neither acid nor alkali, is neutral in its reaction, and is not acted upon by either an acid or an alkali, and therefore cannot enter into direct chemical combination with any organic substance. From the above it would seem that any action of kerosene in steam boilers is not due to a dissolving or chemical softening of the scale. As we know, however, that kerosene will throw down a large deposit in a boiler that is medium scale-coated, its action is certainly positive, and if not chemical must be mechanical. An examination of scale that has been precipitated by oil shows that on its under surface, where it was attached to the shell plates, a reddish-brown coating is observed. Carefully scraping this portion from the body of the scale and subjecting it to chemical analysis, we have for ordinary samples:

	Percent.
Organic and volatile	4
Calcium sulphate	8
Iron oxide	88

Showing that iron oxide or rust is the principal ingredient. The action of the kerosene is as follows: Being very penetrative, it soaks through the body of the scale until it reaches the boiler shell, which it induces to unite with oxygen, forming iron oxide; this compound occupying more space than the iron itself, it consequently pushes or flakes off patches of scale by virtue of its own expansion. Therefore, although it may be readily admitted that oil of this kind is beneficial in removing scale, it is also true that it induces oxidation or rusting, and in aggravated cases may eventually become more harmful as an antidote than the evil which it was intended to eliminate. So-called crude oil, or crude petroleum, is often substituted for kerosene. When of known purity its use by a sight-feed system is not objectionable; in its commercial form, however, it often contains asphaltum, tallow and grease, which are injurious.

CHLORIDE OF MAGNESIUM.

Among the corrosive elements found in feed water, chloride of magnesium ranks in about third place. In cold water its pitting qualities are inactive, but under the influence of heat it decomposes, liberating free hydrochloric acid. In water where carbonate of lime is present in a proportionate degree (¼), the magnesium chloride is neutralized, and its corrosive qualities rendered inactive, the resultant reaction producing calcium chloride, magnesia and carbonic acid gas. Heating the feed water in a separate vessel beyond the critical temperature and treating with carbonate of soda, will in most cases sufficiently counteract the corrosive affects of chloride of magnesium, as found in feed water, so as to render its effects non-injurious.

Sulphurous and other acids, as found in mining districts, are among the most troublesome ingredients to overcome or counteract. In many cases where no other source of supply is available, the problems of treating are quite complex or expensive, hence, among the non-progressive, are often entirely ignored. The action of these acids on boiler shells are extremely varied. At times pitting and corrosion is manifest only along the waterline, within a vertical range of 8 to 10 inches; sometimes the shell from the bottom to the fireline along the center course or at either head presents an appearance as shown at Fig. 5. Also at the girth seam laps below the waterline, where there is a minute volume of dead water adjacent to the projecting edge of the lap, the action is especially violent, as it is in a measure protected from free circulation. Fig. 6 is a typical illustration of the above. In corrosive water, where free circulation can be maintained, the sweep of the moving volume, when positive, prevents the adhesion of the corrosive acids to the plates. In certain types of boilers, however, there are large areas where the circulation is very feeble, and it is at these portions that the reaction is most noticeable, bearing a striking resemblance at times to the appearance of a plastering of grease or butter into which a handful of gravel has been thrown. Heat and chemical treatment are applied in various ways as an antidote; several firms in this country make a specialty of supplying treating apparatus after having studied the local conditions. Their advice and system is to be recommended in all cases. Pressure vessels of the varied industries suffer but little from scale. Chemicals, however, play a wholesale part in their destruction. Their uses, the various acids and reagents will be taken up in an early issue.

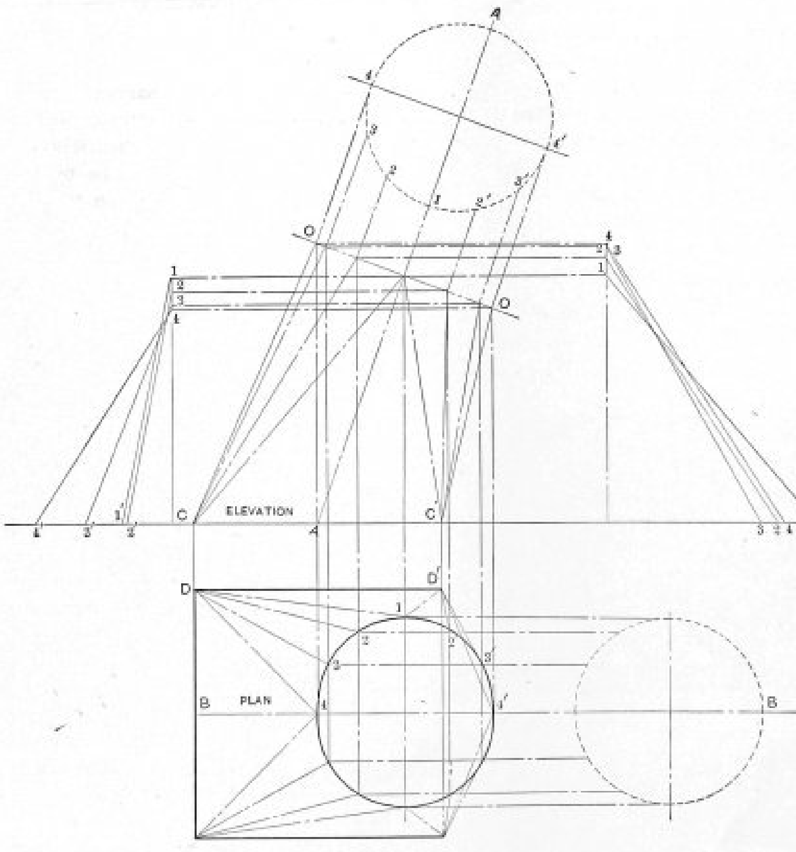


FIG. 1.

It is not always necessary for scale or deposit to form on the surface of a boiler plate to cause overheating. The boiler may be kept clean, but through undue forcing and very heavy firing the double thickness of plate of a circumferential seam may easily become overheated, forming cracks from the rivet holes to the edge of the plate, or if the seam is double riveted on the inside of the joint between the two rows of rivet holes.

LAYOUT OF A TRANSITION PIECE.

BY C. B. LINSTROM.

A transition piece, tapering from round to square and setting other than at right angles to the surface it connects, is met with quite frequently in sheet metal work. It is used for conveyors and in many fan connections in blast-pipe work. The problem can be very readily solved by triangulation.

CONSTRUCTION.

First draw the plan and elevation, as shown in Fig. 1, to the required dimensions of the transition piece. It will be seen from the drawing that it will be necessary to make a development of the circle for the plan view. This is due to the fact that in looking directly down upon the object, the round portion of the transition piece will be seen foreshortened, or elliptical in shape. To develop this foreshortened view the same principles are applied as are used in projection drawing. On the line *A-A*, which is the axis of the transition piece, and at a convenient distance from the object, draw a circle equal in diameter to the circular portion of the object. Divide the circle into any number of equal spaces, in

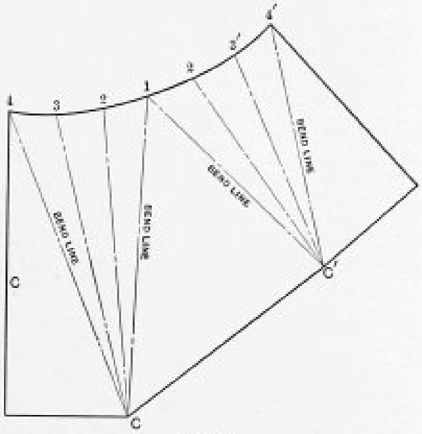


FIG. 2.

this case six. At right angles to the line 44' extend these points of division until they intersect the line o-o. On the line *B-B*, and at a convenient distance from the plan, draw a circle equal in diameter to the circle drawn in the elevation, and divide it into the same number of equal spaces. Extend these points of division parallel with the line *B-B* to the plan view. Then at right angles to the line *B-B* drop the corresponding points from the side elevation until they intersect the lines just drawn in the plan. The intersections of these respective lines determine the development of the foreshortened view of the transition piece.

In both plan and elevation, draw in the dotted construction lines from the points, as shown from *C* to 4-3-2-1 and *C'* to 1-2'-3' and 4' in the side elevation, and from *D* to 4-3-2-1 and *D'* to 1-2'-3'-4' in the plan.

The next procedure is to determine the true length of lines for the development of the pattern. This is done in the usual way, by constructing triangles, obtaining the heights from the elevation and the base from the plan. The hypothenuses of these respective triangles are the required lines, or the true length of lines, used in developing the pattern. As the operation of constructing these triangles is so simple a description of the various operations involved will not be necessary.

LAYOUT OF THE PATTERN.

First, draw the vertical line *c*, making it equal in length to the line *C* to *O* of the side elevation. Then set the dividers, or trammel points, equal to the distance from *D* to *B* of the plan view, and using 4 as a center, draw an arc. With the dividers set equal to the distance 4-4 of the triangles, and using *4* in the pattern as an apex draw an arc, cutting the arc just drawn, thus locating the point *C*. The spaces for the stretchout at the top will be taken either from the circle in the side elevation or from the circle on the line *B-B*. This is immaterial, as both are of the same diameter, and are divided into the same number of equal spaces. It is good practice when developing patterns for pieces of this kind, where the spaces are equal, to use two pairs of dividers, or trammels, setting one pair for the spaces and using the other for the construction lines.

With 4 as an apex and using the spacing dividers, draw an arc; then set the trammels equal to the distance 3-3 of the triangles, and using *C* as an apex draw an arc, cutting the arc just drawn, as shown at 3. Continue in this manner, using alternately the spacing dividers and the distances from 2 to 2 and 1 to 1 of the triangles, thus constructing the large portion of the transition piece, as shown within the points *C*-1-4-*C*. To construct the remaining portion of the half pattern, set the trammels equal to the distance *D-D'* of the plan, and with *C* as an apex draw an arc. Then with the dividers set to the distance from 1' to 1 of the triangles, and with 1 in the pattern as an apex, draw an arc, cutting the arc just drawn, thus determining the distance in the base from the point *C* to *C'*. The remainder of the pattern is now developed in the same manner as given for developing the larger portion. The placing of the seams, amount of lap and spacing of rivet holes are to be made at the discretion of the mechanic when laying out the pattern.

THE PERSONAL FACTOR IN CONNECTION WITH THE CARE AND INSPECTION OF BOILERS AND MACHINERY.*

BY J. W. RAUSCH.

It is an old axiom that "Men are different and always will be different." I question whether there is anyone who appreciates this more keenly than an inspector who is constantly in touch with all kinds and manner of men. Indeed, I feel sure that you inspectors will agree with me that there is often a very material difference of opinion regarding things about a plant, especially if the question pertains to the necessity or practicability of guarding certain machinery, and it is this difference of opinion that brings into play the various personal factors which often make the inspector's duty a most trying one. At some plants care is exercised to keep everything in first-class condition. The work is done in an orderly and systematic manner, and everything possible consistent with the nature of the business appears to be done for the welfare and safety of the employees. It is a pleasure to make an inspection at a plant of this kind, not because the inspection is less thorough, but the inspector knows that if he does find anything which is dangerous and liable to cause accident, such dangerous defects will be remedied if a practical way can be devised.

Unfortunately, however, there are many plants where the conditions are just the opposite. The inspector at the outset is looked upon with suspicion. The superintendent or manager at the plant may be more interested in turning out large quantities of goods at the least possible expense than in the safety of the employees. He may be aware of the fact that certain safeguards recommended by the inspector are absolutely necessary for safety, but is afraid that they will hamper the work, and instead of giving the improvements a fair trial, a letter is liable to find its way to the office of the chief inspector, complaining that the inspector is too critical and is insisting upon impracticable things. Thoroughly com-

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petent engineers are sometimes of an exceedingly jealous and sensitive disposition, and are under the impression that their ability is questioned when an inspection is made of the machinery, boilers and other appurtenances of which they may be in charge. This is all wrong. Banks and trust companies are periodically examined by government examiners, yet no one would question the ability of the officials of the banks and trust companies because of such examination.

It should be remembered in these times of rapid development that new appliances and devices are constantly being put on the market. This appears to be especially true in the engineering line, and we must indeed be wideawake if we wish to keep abreast of the times. The inspector visits different plants every day, and the very nature of his work is such that he picks up information and acquires a knowledge of matters pertaining to steam plants that could not be obtained in any other way. It is, therefore, reasonable to suppose that he can often suggest improvements even to the competent engineer, and he may also exchange ideas with the engineer to the mutual benefit of both.

Then, there is the engineer who does things knowing that they are dangerous, but who is reckless and would rather take chances than encounter inconvenience. For example, inspectors often find the governor of an overloaded engine blocked. Strange to say this is being done every day and sometimes with the full knowledge of the management. This practice cannot be condemned too severely, for while the engineer may be willing to risk his life and the manager may be willing to run the chances of a heavy property loss, they certainly have no right to jeopardize the lives of the employees and other persons who may be about the plant. Blocking the safety attachment of a passenger elevator is another favorite pastime with some men, who do this rather than take the trouble of adjusting the governor to the proper speed limit. The necessity of keeping safety attachments in proper working order cannot be too strongly emphasized. It is true that no mechanical device is absolutely reliable under all conditions, but thorough inspection and the proper care of safety attachments have in actual experience prevented many accidents.

It may not be amiss to say a few words regarding the engineer who depends entirely upon his subordinates. It is true that the responsible head of a large engineering plant cannot be expected and neither would he have the time to look after every detail, but as is shown by my own experience, which is only one of many, a personal inspection now and then will often pay well.

In citing the above cases, I have tried to bring out a few of the conditions met with by the inspector, but how about the inspector himself? Is he always courteous, and is he always clear and concise in his recommendations? Then, too, I believe we will have to admit that inspectors, like doctors, do not always agree, and that in a controversy it is not always the fault of the management at the factory. The old adage that "You can catch more flies with sugar than with vinegar" cannot be more forcibly illustrated than when making inspections. The inspector with the requisite amount of tact and diplomacy can say things the right way. He will succeed in having improvements made where the other man will make an utter failure. If, for example, there is anything that makes a manager or superintendent indignant, it is to have an inspector come around and criticize or find fault with certain dangerous conditions without being able to show in a clear, concise and practical way how the danger can be overcome. Again, owners and managers do not like to have matters pertaining to their plants discussed by outside persons, especially if dangerous conditions are alluded to. If then the inspector finds anything about a plant which is dangerous, he should confine his remarks to the proper person or persons, and submit his report according to the instructions of his chief. It may at times be advisable, in order to emphasize the necessity of certain safeguards, to refer to other plants, and if the inspector will use discretion there can be no harm in this. On the contrary, it will go a long way toward convincing the management that certain safeguards are necessary if he can show from actual experience that accidents have occurred due to the lack of them.

In conclusion, I wish to say that the above criticisms are made in the most friendly spirit, and I hope that our good friends referred to and you inspectors will accept them in the same spirit. What we need is a better understanding between the management at the plant and the inspectors. Let the owners know that inspections are not made with a view of criticising or finding fault, but that we want to help them. We are all working for one common good, and in order to obtain the best results we must co-operate with each other.

THE RIVETED JOINTS OF CYLINDRICAL BOILERS

H. K. SPENCER, CHIEF ENGINEER U. S. R. C. S.

Assume that the diameter of the boiler shell has been determined and the quality of the material to be used in its construction has been selected, and all the necessary data are at hand for designing the riveted joints of the boiler. Only those joints commonly used in cylindrical boilers will be discussed; they are the single, double and triple riveted lap joints, and the double and triple riveted, double butt-strapped butt joints.

Let

P = working pressure in pounds per square inch,
R = inside radius of cylindrical shell in inches,
t = thickness of shell in inches, and
T = tensile strength of material in pounds per square inch of section.

The total pressure tending to burst the cylindrical shell of the boiler longitudinally is, if the length of the shell is 1 inch, $2 \times R \times 1 \times P$, which is resisted by two sections of metal each 1 inch long and t inch thick, having a tensile strength T pounds per square inch, so the equation can be written,

$2 \times R \times 1 \times P = 2 \times 1 \times t \times T$, and $R\ P = T\ t$......(1.)

The pressure tending to tear the shell apart circumferentially is $P \pi R^2$, which is resisted by a section of metal of $2\pi\ (R + 1/2t)\ T$ square inch, so $P \pi R^2 = 2\pi\ (R + 1/2t)\ T$, and $R\ P = 2tT\ (1 + t2R)$..........................(2.), from which it is seen that a boiler is a little more than twice as strong circumferentially as it is longitudinally.

To obtain the maximum economy of material in a riveted joint it should be so proportioned that it will be no more liable to rupture by the tearing apart of the plate than by the shearing of the rivets, or by the failure of the plate or rivets by crushing. In lap joints and butt joints with single butt straps the rivets are in single shear, while in butt joints with double butt straps they are in double shear. The shearing strength of rivet steel is about 0.8 of its tensile strength, and the strength of a rivet in double shear is considered to be 1.8 times the strength of the same rivet in single shear. Steel is used almost entirely for boiler construction.

T = 60,000 pounds per square inch,
S = 48,000 pounds per square inch, shearing strength of rivets, and
C = 66,000 pounds per square inch, strength of plate and rivets in compression.

A factor of safety of 4.5 is sufficient to insure bringing the working strength well within the elastic limit of the material.

Equation (1.) shows that the strength, longitudinally, of a plain cylindrical shell to resist a bursting pressure is independent of its length, so a girth strip of length equal to the pitch of the rivets can be considered. Let

p = the pitch of the rivets in inches, and

d = the diameter of the rivets in inches.

From equation (1.), the strength, longitudinally, of a cylindrical shell, made with a perfectly welded joint, is expressed by

$p\,R\,P = T\,p\,t$, and $t = R\,P/T$ .... (3.)

Any riveted joint is weaker than the plate, because a certain amount of the material of the plate must be cut out for the line of rivets, so the thickness must be greater than that of the cylindrical shell, perfectly welded.

SINGLE LAP RIVETING.

The single riveted lap joint is the simplest, but it is never used except for joints exposed to the fire, where tightness only is essential in the seam, and for the girth seams of boilers of small diameter, for moderate working pressures. To show the low efficiency of this style of joint, supose the longitudinal seam of a boiler to be a single riveted lap joint. The inside diameter of the shell is taken as 72 inches, and the working pressure as 80 pounds per square inch. Referring to Fig. (1.), and considering a ring of width (p), it is seen that the plate, at the line of rivets, has a section of $(p - d)\ t$ square inch and the strength of the shell, in tension, then is, from equation (1),

$p\,R\,P = 60{,}000\ (p - d)\ t$ .... (4.),

and the strength to resist shearing is

$p\,R\,P = 48{,}000\pi d^2/4$ .... (5.),

and the resistance to crushing is, taking the projected area of the rivet as the area of rivet and plate in compression,

$p\,R\,P = 66{,}000\ d\ t$ .... (6.)

It is seen that all these expressions are equal, therefore, combining (4) and (6) gives

$60{,}000\ (p - d)\ t = 66{,}000\ d\ t$, and $p = 2.1\ d$ ...... (7.)

The efficiency of the joint is

$[(p - d)\ /p] \times 100 = [(2.1d - d) \div 2.1d] \times 100 = 52.38$ percent.

Combining (5) and (6) gives

$48{,}000\pi d^2/4 = 66{,}000\ dt$, and $t = 0.5712\ d$ .... (8.)

For the 72-inch boiler, the value of d can be found from equation (6) by substituting in it the values of p from (7), and t from (8), and the known quantities R and P, and introducing the factor of safety, 4.5. Then

$2.1\ d \times 36 \times 80 = (66{,}000/4.5) \times 0.5712\ d^2$.

$d = 0.7219$ inch.

$t = 0.5712\ d = 0.4124$ inch.

$p = 2.1\ d = 1.516$ inch.

DOUBLE LAP RIVETING.

The double-riveted lap joint is frequently used for the longitudinal seams of boilers of small diameter and moderate working pressures and for the girth seams of large boilers to carry high pressures. For comparison with the single riveted lap joint, suppose the longtitudinal seam of the boiler under consideration to be a double-riveted lap joint. The riveting may be arranged either as in Fig 2, called chain riveting, or as in Fig. 3, called staggered or zigzag riveting; the latter is generally used, as it gives the same strength as chain riveting, with less material in the lap.

As before, consider a ring of width equal to the pitch of the rivets. For tensile strength, equation (4) is used unmodified, and $p\ R\ P = 60{,}000\ (p - d)\ t$.

In this joint there are two rivets to take the shearing and crushing stresses, so equations (5) and (6) are modified, respectively, to

$p\ R\ P = 48{,}000 \times 2\pi d^2/4$ .... (9.)

$p\ R\ P = 66{,}000 \times 2d\ t$ .... (10.)

Combining (4) and (10) gives

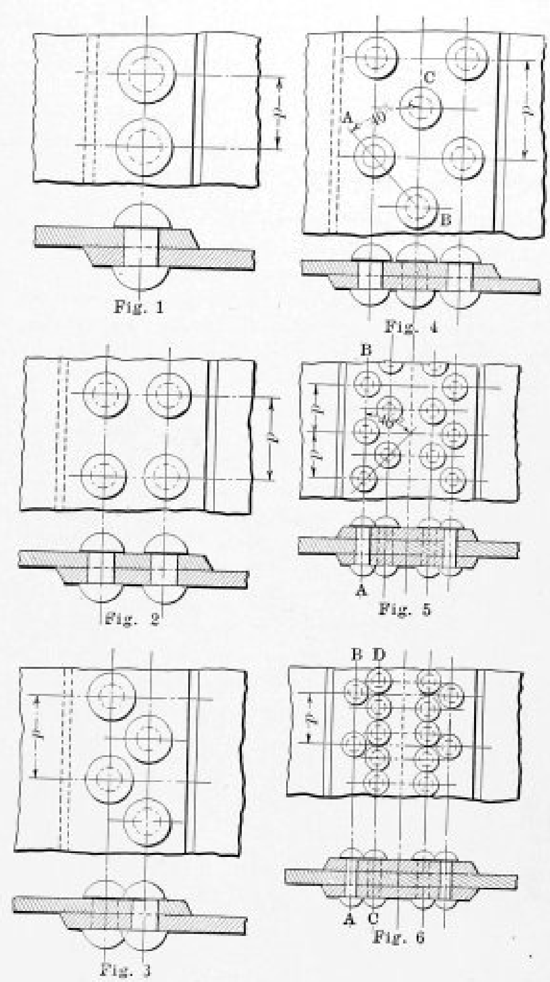
$60{,}000\ (p - d)t = 66{,}000 \times 2\ d\ t$, and $p = 3.2\ d$. (11.)

The efficiency is $(3.2d - d)\ /\ 3.2d \times 100 = 68.75$ percent.

Similarly, combining (9) and (10) gives

$48{,}000 \times 2\pi d^2/4 = 66{,}000 \times 2\ d\ t$, and $t = 0.5712\ d$. (12.)

Substituting the values of p and t, as given by equations (11) and (12), in equation (10) gives, using, as before, a factor of safety of 4.5, $3.2d \times 36 \times 80 = (66{,}000\ /4.5) \times 2 \times 0.5712\ d^2$, and



LAP AND BUTT JOINTS.

$d = 0.5504$ inch,

$t = 0.5712\ d = 0.3142$ inch,

$p = 3.2\ d = 1.763$ inch.

TRIPLE LAP RIVETING.

In a triple-riveted lap joint, Fig. 4, there are three rivets in single shear, and three to take the crushing stress, so the equations for this style of joint are as follows: Equation (4),

$p\,R\,P = 60{,}000\ (p - d)\ t$,

$p\,R\,P = 48{,}000 \times 3\pi d^2/4$ .... (13.)

$p\,R\,P = 66{,}000 \times 3\ d\ t$ .... (14.)

combining (4) and (14) gives $p = 4.3\ d$ .... (15.)

The efficiency is $[(4.3d - d)\ /\ 4.3d] \times 100 = 76.74$ percent.

Combining (13) and (14) gives $t = 0.5712\ d$.... (16.)

Substituting the values of p and t, as given by (15) and (16), in (14), introducing the factor of safety, 4.5, and the values of R and P, as used before, gives

$d = 0.4927$ inch,
$t = 0.5712\ d = 0.2815$ inch,
$p = 4.3\ d = 2.119$ inches.

In staggered riveting, the distance between the rows of rivets must be such that the plate will not tear obliquely between the rivets. Here the metal is subjected to a combined tension and shearing stress. By making the angle *ABC*, Fig. 3, about 40 degrees, sufficient strength is given and the distance between rows of rivets is about 0.42 *p*, as a minimum.

BUTT JOINTS.

For butt joints with single butt straps the same diameter of rivets, thickness of plate and pitch of rivets would be obtained as with lap riveting, though double the number of rivets would be used. The butt strap should be the same thickness as the plate.

DOUBLE BUTT STRAPS, DOUBLE RIVETING.

A double-riveted butt joint, with double butt straps, is shown in Fig. 5. Such seams can be used for the longitudinal seams of boilers of small diameter for moderate working pressures. It will be considered as applied to the 72-inch boiler for 80 pounds pressure, for comparison with the double-riveted lap joint.

It is evident that the section of plate along the line *AB* is the one to be considered in calculating the tensile strength, and the section of plate in tension is $(p - d)\ t$. Each rivet presents two sections to resist shearing. Putting the shearing strength equal to the crushing strength gives an equation similar to (12), but in this case the rivets are in double shear, and hence have a value 1.8 times that given by (12), and

$t = 0.5712\ d \times 1.8 = 1.028\ d$ .... (17.)

As was done with the lap joints, the tensile strength of the plate section can be placed equal to the strength of the rivets or plate in compression, and equations (4) and (10) hold true here, so $p = 3.2\ d$, and the efficiency is the same as for double lap riveting, 68.75 percent.

Substituting as before, and using the same factor of safety, gives $3.2\ d \times 36 \times 80 = (66{,}000 / 4.5) \times 2 \times 1.028\ d^2$, and

$d = 0.3056$ inch.
$t = 0.3142$ inch,
$p = 0.9778$ inch.

It is seen that, while this joint gives the same efficiency and thickness of plate as the double-riveted lap joint, it gives a different proportion of rivet diameter to plate thickness. For strength alone the butt straps need be only one-half as thick as the plates, but for tightness and rigidity they are made equal to three-fourths of, or to the plate thickness. The angle *ABC* must not be less than 40 degrees.

The double-riveted, double but strapped joint, when used, should be made as in Fig. 6, with alternate rivets in the outer rows omitted. In this joint the pitch is taken as the distance between centers of the outer rivet holes; that is, along the line *AB*. The tendency to rupture must be no greater along the line *CD* than along the line *AB*. The section of plate at *AB*, to resist tension, is $(p - d)\ t$, and its strength is expressed by equation (4), while that along *CD* is $(p - 2d)\ t$, but the weaker section at *CD* is compensated for by the rivet sections in the outer row, which must be sheared by the bursting pressure, in addition to tearing the plate along the line *CD*. The total resistance to rupture along that line is expressed by the equation

$p\ R\ P = 60{,}000\ (p - 2d)\ t + 48{,}000 \times 1.8\pi d^2/4$. (18.)

For shearing, the strength is expressed by

$p\ R\ P = 48{,}000 \times 3 \times 1.8\pi d^2/4$ .... (19.)

For compression, the equation is the same as (14).

As all these expressions are equal,

$60{,}000\ (p - 2\ d)\ t + 48{,}000 \times 1.8\pi d^2/\ 4 = 60{,}000\ (p - d)\ t$, which, rewritten, expresses the condition for equal strength along *AB* and *CD* as $60{,}000\ d\ t = 48{,}000 \times 1.8\pi d^2/4$ .... (20.)

$t = 1.131\ d$ .... (21.)

Equation (20) shows that the rivets in the outer rows must have a shearing strength equal to the amount by which the tensile strength of the plate at the inner row is reduced, by the additional rivet hole in that row.

Putting the tensile strength equal to the crushing strength, $60{,}000\ (p - d)\ t = 66{,}000 \times 3\ d\ t$, and

$p = 4.3\ d$ .... (22.)

The efficiency of the joint is the same as for the triple-riveted lap joint, 76.74 percent.

This style of joint is used for the longitudinal seams of boilers for moderately high working pressures. Suppose it to

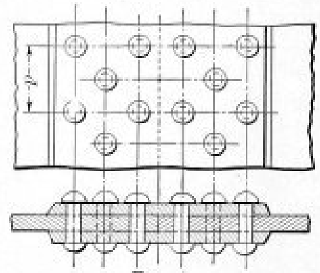


Fig. 7

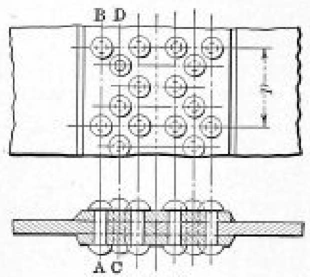


Fig. 8

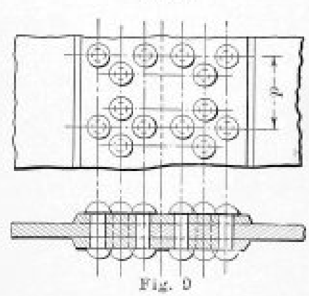


Fig. 9

be used in a 72-inch boiler to carry 80 pounds pressure, then, using a factor of safety of 4.5.

$d = 0.2489$ inch,
$t = 0.2815$ inch.
$p = 1.071$ inches.

For a 12-foot boiler, to carry 120 pounds pressure,

$d = 0.7466$ inch,
$t = 0.8444$ inch,
$p = 3.197$ inches.

For a boiler 14 feet inside diameter, to carry 160 pounds,

$d = 1.161$ inch,
$t = 1.314$ inch,
$p = 4.994$ inches.

DOUBLE BUTT STRAPS, TRIPLE RIVETING.

Fig. 7 shows a triple-riveted, double butt strapped joint. Each section of width *p* presents three rivets in double shear to resist the shearing stress, and three to withstand crushing. Putting the tensile strength equal to the crushing strength gives $60,000\ (p - d)\ t = 66,000 \times 3\ d\ t$, from which,

$p = 4.3\ d$ ....(23.)

The efficiency is 76.74 percent.

There being three rivets in double shear, the proportion of t to d is the same as that expressed by equation (17), and

$t = 1.028\ d$ ....(24.)

For the 14-foot boiler for 160 pounds working pressure, the results are

$d = 1.278$ inches,
$t = 1.314$ inches,
$p = 5.497$ inches.

The efficiency and thickness of plate are the same as obtained with triple lap riveting and double butt riveting, omitting alternate rivets in the outer rows.

The triple-riveted, double butt strapped joint, when used for boilers to carry high pressures, is made with the alternate rivets in the outer rows omitted, as in Fig. 8. The pitch is taken as the distance between centers of rivets in the outer rows. Here for each pitch there are five rivets in double shear, and five to resist crushing. The joint must not be more liable to fail along CD than along AB, so here again the condition must be $60,000\ d\ t = 48,000 \times 1.8\pi d^2/4$, and $t = 1.131\ d$. (25.)

Equations, one similar to that from which (23) was derived, expressing equal strength along AB and CD, and one giving the strength in compression, can be written, and

$60,000 (p - 2d)\ t + 48,000 \times 1.8\pi d^2/4 = 60,000\ (p - d)\ t$
$= 66,000 \times 5\ d\ t$, and $p = 6.5\ d$ ....(26.)

The efficiency is 84.61 percent.

For a boiler 14 feet in diameter, to carry 160 pounds pressure,

$d = 1.053$ inches,
$t = 1.191$ inches,
$d = 6.846$ inches.

The triple-riveted joint is sometimes made, as in Fig. 9, with not only the alternate rivets in the outer rows omitted, but also the alternate ones in the inner rows. The condition, $60,000\ dt = 48,000 \times 1.8\pi d^2/4$, must also be kept here, and again, $t = 1.131\ d$.

There are four rivets in double shear and four in compression for each pitch, and $p = 5.4\ d$. The efficiency is 81.48 percent.

For the 14-foot boiler,

$d = 1.094$ inches,
$t = 1.237$ inches,
$p = 5.907$ inches.

The most efficient triple-riveted butt seam is obtained by the arrangement of rivets shown in Fig. 10, where the number of rivets per pitch is reduced by one in each row, outward from the butt. Here again the condition must be kept, that $60,000\ d\ t = 48,000 \times 1.8\pi d^2/4$, and $t = 1.131\ d$.

There are six rivets in double shear and six in compression in each strip of width p, which is the distance between rivet centers in the outermost row, and $p = 7.6\ d$, which makes the efficiency 86.84 percent.

For a 14-foot boiler, to carry 160 pounds,

$d = 1.003$ inches,
$t = 1.134$ inches,
$p = 7.622$ inches.

A form of triple-riveted butt joint is shown in Fig. 11. It is used for the longitudinal seams of locomotive boilers which have diameters as large as 84 inches and carry pressures up to 220 pounds per square inch. It is seen that in each strip of width p, which is taken as the distance between rivet centers in the outermost rows, there are four rivets in double shear and one in single shear, and that there are five rivets to resist crushing. The resistance to rupture along CD must equal that along AB; that is, the tensile strength of the plate at CD, plus the strength of the rivets in the outermost row in single shear, must be equal to the tensile strength of the plate along AB, or algebraically, $60,000\ (p - 2d)\ t + 48,000\pi d^2/4 = 60,000$

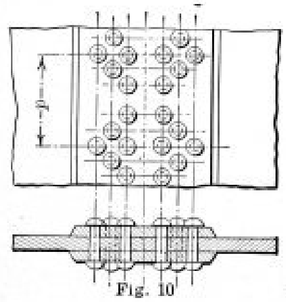


Fig. 10

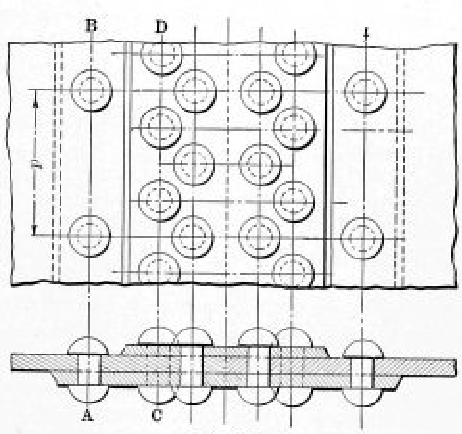


Fig. 11

$(p - d)\ t$, which imposes the condition, $60,000\ d\ t = 48,000\pi d^2/4$, and $t = 0.6283\ d$ ....(27.)

For equal strength to resist tearing, at AB or CD, shearing and compression, the equations can be written,

$60,000\ (p - 2d)\ t + 48,000\pi d^2/4 = 60,000\ (p - d)\ t =$
$66,000 \times 5\ d\ t$, and $p = 6.5\ d$ ....(28.)

The efficiency is 84.61 percent, the same as for the joint shown in Fig. 8.

For a 14-foot boiler for 160 pounds working pressure,

$d = 1.896$ inches,
$t = 1.191$ inches,
$p = 12.32$ inches.

For a locomotive boiler 78 inches inside diameter, to carry a working pressure of 200 pounds, the results are

$d = 1.103$ inches,
$t = 0.693$ inch,
$p = 7.169$ inches.

From equations (25) and (26), for the same boiler,

$d = 0.613$ inch,
$t = 0.693$ inch,
$p = 3.983$ inches,

and, if made as in Fig. 10,

$d = 0.5957$ inch,
$t = 0.6737$ inch,
$p = 4.527$ inches.

Made as in Fig. 11, with the narrow butt strap outside, a good calking edge is presented, with the minimum distance between rivets, so the arrangement not only gives high efficiency, but insures tightness, where comparatively thin plates are used. It is seen that such riveting would be impracticable for boilers of large diameters, for high pressures, because of the large diameter of rivet necessary.

Figs. 1 to 6, inclusive, are drawn to the same scale and show the results obtained by applying the different styles of riveting to a boiler 72 inches in diameter to carry 80 pounds pressure. Figs. 7 to 11, inclusive, are also drawn to the same scale, and are calculated for the 14-foot boiler. For convenient comparison, the results obtained by applying the different styles of riveting, as shown by Figs. 6 to 11, inclusive, to the longitudinal seams of a 14-foot boiler to carry a working pressure of 160 pounds, are tabulated below. $2n$ = number of rivets per pitch. N = number of rivets in a seam 10 feet long. E = efficiency, percent.

FIGURE.	d.	t.	p.	$2n$.	N.	E
6	1.161	1.314	4.994	6	144	76.74
7	1.278	1.314	5.497	6	132	76.74
8	1.053	1.191	6.846	10	176	84.61
9	1.094	1.237	5.907	8	164	81.48
10	1.003	1.134	7.622	12	190	86.84
11	1.896	1.191	12.32	10	98	84.61

If, instead of using the riveting shown in Fig. 7 for the 14-foot boiler, that shown in Fig. 8 was used, a saving of 2,360 pounds in the weight of the shell would result, by using that shown in Fig. 9, 1,480 pounds, and by using that shown in Fig. 10, 3,450 pounds.

In general, it may be said that the efficiency of the double butt strapped joint can be indefinitely increased by increasing the number of rows of rivets, while decreasing the number of rivets in each row by one, outward from the butt of the plates. Then, if the condition, $S \times 1.8\pi d^2/4 = T\ d\ t$, is maintained, the joint will be equally strong along each row of rivets, and the section plate at the outer row of rivets is the measure of the efficiency.

GENERAL RULES.

A quality of material, giving different values of T, S and C than those assumed by the writer, would often be used, so general expressions for t and p, in terms of d, are given. Let n equal one-half the number of rivets in a girth strip of width equal to the pitch.

For lap joints,

$t = 0.7854\ d\ S/C$, or $d = 1.273\ t\ C/S$..........(29.)

$p = (Cn - T)d/T$..........................(30.)

For butt joints with double straps, all rivets in double shear,

$t = 1.414\ d\ S/C$, or $d = 0.8903\ tC/S$...........(31.)

For double butt joints all rivets in double shear and alternate rivets in the outer rows omitted,

$t = 1.414\ d\ S/T$, or $d = 0.8903\ t\ T/S$...........(32.)

If the rivets in the outer rows are in single shear,

$t = 0.7854\ d\ S/T$, or $d = 1.273\ t\ T/S$..........(33.)

For the last three cases, the general expressions for the relations of p to d are the same as (30).

An extra 1/16 inch is usually added to the thickness of plate found by the formulæ, as an allowance for corrosion, so the designed pressure may be carried until the plates have lost that much in thickness.

GIRTH SEAMS.

The pressure acting to tear the boiler apart circumferentially is $P\ R$. Equations (1) and (2) show that the shell itself, as designed for strength longitudinally, is twice as strong as need be to resist rupture circumferentially, so, in the girth seams, the shearing strength of the rivets is all that need be considered. Assuming that the rivets in the girth seams are the same size as those in the longitudinal seams, and calling the total number of rivets in the seam (n_1), the equation for their shearing strength is

$P\pi R^2 = (48{,}000/4.5) \times n_1\pi d^2/4$, and $n_1 = 3\ P\ R^2/8{,}000d$. (34.)

The length of the seam to be riveted is $2\pi\ (R + t)$ inches, so, if n_2 is the number of rows of rivets in the seam, the pitch of the rivets will be

$p_1 = 2\pi n_2\ (R + t)\ /\ n_1$.......................(35.)

For a boiler 14 feet in diameter, to carry a working pressure of 160 pounds, $d = 1.053$ inches for the longitudinal riveting, if as in Fig. 8, and $n_1 = 382$, and then, from (35), using the proper value of t, $p_1 = 2.804$ inches, the girth seams being double-riveted lap joints.

CENTER OF RIVET TO EDGE OF PLATE.

In all riveting, the distance from the center of the rivet hole to the edge of the plate must be such that the plate in front of the rivet will not fail, as in Fig. 12, by tearing apart, and also there must be no possibility that the metal will shear out along the lines ab and cd. The latter will not occur in lap joints when $2\ l_1\ t\ S$ is greater than $\pi d^2 S/4$, or in double-strapped butt joints when $2\ l_1\ t\ S$ is greater than $1.8\pi d^2\ s\ /\ 4$

The metal directly in front of the rivet is subjected to a stress similar to that of a beam fixed horizontally at both ends,

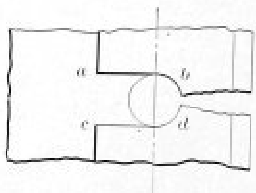


Fig. 12.

and loaded in the middle. The length of the beam is d, the diameter of the rivet; its depth is $l_1 - \frac{1}{2}\ d$, and its breadth is t. The load, which will be called P_1, is that tending to shear one rivet, and is equal to the load tending to rupture a ring of the shell of width equal to the pitch, so, if n is taken to represent the number of rivets in a lap joint, or one-half the number in a butt joint, for each strip of width p, $P_1 = p\ R\ P/n$. (36.)

From the equation for safe loading for a beam fixed horizontally at both ends, with a single load in the middle, calling the ratio, $t\ /\ d = n_3$, $l_1 = d\ /\ 2 + \sqrt{P_1\ /\ 16{,}000\ n}$ ....(37.)
or, substituting the value of (P_1),

$l_1 = d\ /\ 2 + \sqrt{p\ R\ P\ /\ 16{,}000\ n\ n_3}$...............(38.)

For the 14-foot boiler, with riveting as in Fig. 8, $d = 1.053$ inches, $t\ /\ d = 1.131$, $p = 6.846$ inches, and, substituting these values in (38), $l_1 = 1.52$ inches.

In calculating the stays for the flat surfaces in a boiler, it is not considered that the material in the surface supported has any value in resisting the bursting pressure. Whenever possible the stays should be so spaced as to permit a man to pass between them; this can always be done with the through braces above the tubes, where the plates can be reinforced by large washers riveted to the plates supported. Here the pitch is seldom greater than 16 inches. Calling the pitch of the stays p^2, the load each stay supports is $p^2_2 \times P$, P being the boiler pressure. Each square inch of net section of the stay should safely support a working load of 10,000 pounds (working stress allowed by Lloyds), so, calling the diameter of the stay d_2, the equation for its strength is

$p^2_2 P = 10{,}000\pi d^2_2/4$, and $d_2 = .0113\ p_2 \sqrt{P}$......(39.)

Let $p_2 = 16$ inches and $P = 160$ pounds, then $d_2 = 2.279$ inches.

The fire surfaces of a boiler have a thickness of ½ inch to ⅝ inch, and the plate cannot be reinforced with washers, so the strength of the square of plate supported by four stay bolts is considered. Its support is such that the square of plate can be considered as a beam fixed horizontally at both ends, and the load uniformly distributed over the whole upper surface. Call the pitch of the stay bolts p_3 and the thickness of the plates t_2, then, from the formula for the safe loading of a beam fixed horizontally and uniformly loaded,

$$p_2 = 155\, t_2 \sqrt{1/P} \quad \text{.....(40.)}$$

where P is the boiler pressure.

Applying the above to a boiler with ½-inch sheets in the back connection, to carry 160 pounds working pressure, gives $p = 6.13$ inches.

Allowing these stay bolts a safe working load of 8,000 pounds per square inch of net section, as allowed by Lloyds for such stays, their diameter is

$$d = .0127\, p_2 \sqrt{P} \quad \text{.....(41.)}$$

Let $p_2 = 6.13$ inches, and $P = 160$ pounds, then $d_2 = 0.9845$ inch.

The top sheet of the combustion chamber must be supported by stays, but here it is not practicable to stay one sheet to another, so these stays are carried on girders, bridging the top of the fire-box from the back-tube sheet to the back sheet of the combustion chamber. The depth of the combustion chamber is generally such that three stays placed equally distant from the ends of the girders, and from each other, will give a proper

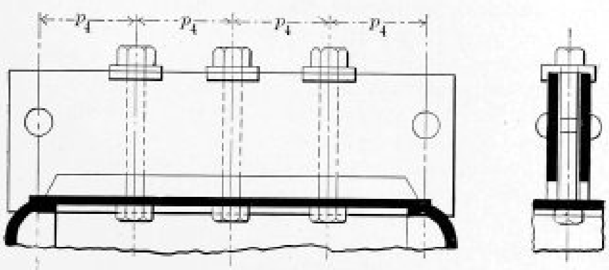


FIG. 13.

pitch for them. The girder is in the condition of a beam supported at the ends and loaded with three loads symmetrically placed. It is made of a pair of plates separated by distance pieces slightly more than the diameter of the stays, and held together by rivets somewhat as in Fig. 13.

Let p_4 be the pitch of the stay bolts along the girder, and p_5 the pitch of the girders. The load on each stay is $P \times p_4 \times p_5$. Let h be the depth of the girder and b the thickness of one plate of the girder, then, from the equation for safe loading for such girder,

$$h = \sqrt{\frac{P\,(l^2_2 p_5 - l_2 p_4 p_5)}{12{,}000\, b}} \quad \text{.....(42.)}$$

where l_2 is the distance in inches between suports.

Very often $l_2 = 4\, p_4$, then $h = .0316\, p_4 \sqrt{\frac{p_5 P}{b}}$ ..(43.)

By making $b = 1/10\, p_5$, which gives a good proportion of thickness of plate to depth of girder, $h = 1\, p_4 \sqrt{P}$..(44.)

Assume, for a boiler to carry 160 pounds, that l_2 equals 24 inches, $p_5 = 7$ inches, and $b = 1/10\, p_6 = 0.7$ inch, then from equation (44) $h = 7.59$ inches.

Convention Announcement.

The annual convention of the International Master Boiler Makers' Association for 1909 will be held at the Sealbach Hotel, Louisville, Ky., April 27, 28, 29 and 30. The hotel has made the following rates: European plan, single room, without a bath, $2 per day; two in a room, $3 per day; $1.50 extra for each additional person in the above rooms. Rooms with a bath, one person, $3, $3.50 and $4; two persons, $4, $4.50 and $5. Any person desiring American-plan rates will find several first-class hotels within a radius of one or two blocks.

SMOKE PREVENTION ON LOCOMOTIVES.

There are three ways of preventing smoke on locomotives. First, by the use of smokeless fuel; second, careful firing; third, the use of mechanical devices which tend to improve conditions for the combustion of bituminous coal. A careful investigation which we have recently made in the motive power departments of the most important railroads in this country brings out the fact that, in order to eliminate the smoke nuisance, about 20 percent use smokeless fuel, at least in cities and on suburban trains, where smoke is most objectionable. About 35 percent depend upon careful firing, having some means of overseeing the work of the firemen, instructing them in proper methods, and keeping a record of the results. Of the devices installed in boilers to aid combustion, brick arches are by far the most popular, and approximately 50 percent of the roads investigated either are using the arch with good results or express themselves in favor of this device. Automatic stokers are not, as yet, sufficiently well developed to give satisfactory service. Theoretically they are looked upon with favor, and most of the railroad officials believe that sooner or later, when the mechanical details have been perfected, their use will become general with beneficial results, both as to coal economy and smoke prevention.

A prominent official writes: "Our experience with automatic stokers, of which we have tried but three designs, does not justify our saying much in their favor or in criticism. So far they have not answered the purposes sufficiently to justify us in making any statement, either in regard to the consumption of coal or the prevention of smoke. In general, we feel that the trend of progress is always in the direction of transferring the heavy, laborious work from the man to the machine, using the man to supervise the work of the machine, and, I believe, the development of the stoker will be on this line. We consider that the stoker has not yet come within sight of meeting this requirement, but believe that the difficulties will, in time, be overcome. Of the devices mentioned, we consider the brick arch, at the present time at least, to be the most promising aid to combustion. We are not, however, relying on mechanical devices to secure this result, for in suburban service we use anthracite; within the limits of the cities, coke; and on freight locomotives and those engaged in certain shifting service, light volatile coal. In this way, with careful firing, we get smokeless combustion and good economy."

A report from another large road favors the use of brick arches, stating that they are used in practically every engine that has sufficient distance between the fire and the bottom flues, which would probably be 75 percent of all their power. The object of the arch is simply this: The arch becomes heated to a high temperature and is practically red hot all the time. It has a tendency to hold the gases in the fire-box for a longer time, because they have to pass under the arch toward the fire door and then up over it before going into the flues; consequently, they are kept at a higher temperature and more complete combustion is obtained. Smoke burners in the form of steam jets are frequently put into the fire-box, or into the front end of the locomotives, where they blow the steam up the smokestack. This simply does one thing—it discolors the smoke. The white steam passing up, particularly in the winter time, when it condenses quickly, forms a white cloud, and the smoke that goes up with it is discolored. The smoke is also moistened by the wet steam, and wherever it settles down on buildings it adheres much more quickly than if the steam was not emitted, because the smoke in itself is lighter and does not settle down so quickly, but, with the steam mixed with it, it is heavy and wet, so that it easily adheres to buildings. For this reason, such devices are not thoroughly endorsed.

Another prominent official writes as follows: "In regard to the general subject of smoke prevention, I have no doubt that a mechanical stoker, if it is possible to construct one, which will properly distribute the coal, would show a marked increase in efficiency of fuel and the prevention of smoke. I have noted the different forms of stokers which have been put on the market, and, in my opinion, none could be satisfactorily applied to a locomotive. A painstaking crew could very likely show good results with them, the same as with any other special device, but for general practice they do not yet seem to be practical. My experience with the brick arch convinces me that, if properly built, it shows good results, both in economy of fuel and prevention of smoke, besides protecting the flues. The principal objections to brick arches are increased liability of the flues stopping up from cinders drawn over the arch and banking up against the flue sheet, and the difficulty in cleaning out the flues when stopped up, as well as the delay and expense necessitated by the removal of the arch to work on the flues. I am convinced, however, that, after all objections are made, a brick arch is an improvement."

On a Southern railway they are attempting to solve the problem of smoke prevention by having the traveling engineers follow up all cases where firemen allow black smoke, and also by the use of brick arches in locomotives which have deep enough fire-boxes to take them. Automatic stokers, steam jets, or any other devices have not been tried, but, with the brick arch and careful firing, it has been found possible to eliminate in the neighborhood of 25 percent of the smoke, while the economy of an engine equipped with a brick arch over one in which there is no arch averages about 10 percent.

The Department of Smoke Inspection of the City of Chicago recently made some quite extensive tests for obtaining accurate information on the possibilities of reducing the amount of moke caused by locomotives within the city limits. A bulletin which has been issued by the department contains a complete account of the tests and a general discussion of the subject.

In considering the matter of blowers for forming artificial draft when the steam is shut off the bulletin states, "Much smoke is caused in locomotive operation by inefficient blower arrangements, either in the cab or in the smoke-box, or by carelessness on the part of the engine crew in not putting whatever blower arrangement their locomotive is equipped with into operation. The only function of the blower as a smoke preventitive is to induce a draft to draw air into the fire-box, in order that there may be enough oxygen supplied, in the absence of a draft produced by the exhaust from the nozzle, to completely burn the coal. The best blower arrangement, therefore, is the one that gives results approaching as nearly as possible the conditions which exist when the engine is working steam."

Tests were made on a number of different types of blowers by the department, and it was found that a combination blower and exhaust tip, adaptable to locomotives having a single nozzle, gave the best results. This consists of a special exhaust tip having an annular chamber into which the blower steam pipe is led. Sixteen ¼-inch openings or jets from the chamber are arranged in a circle around the outside of the nozzle, and so directed that the steam from them forms a single hollow jet, filling the stack near the top. The advantages claimed for this blower are that it induces sufficient draft, is economical in steam consumption and is comparatively noiseless.

On locomotives having a double exhaust tip this arrangement of blower is not practical, and a double blowing arrangement, consisting of two pipes extending up from the nozzle on either side and ending at about the base of the stack, being inclined inward, so as to cause their combined jets to fill the stack near the top, is advocated. The tips of these blowers are flattened down to give a wide, thin jet of steam, the opening being but ¼ inch wide from a 1-inch pipe.

In discussing this subject the bulletin states that "in order to obtain good results no blower connection should be less than 1-inch pipe, and the blower itself should have an aggregate opening of the same size as the pipe. In order to facilitate the operation provision should be made for the engineer and firemen to open the blower independently of each other, or better, to make the means of opening the blower partially or wholly automatic. If it is arranged to be automatic it should open when the throttle is closed and remain open after the throttle has been opened, until the engine has acquired speed enough for the exhaust from the cylinders to furnish sufficient draft." An illustration and description of an automatic blower valve which operates in this manner and is being very successfully used by one of the railroads in Chicago is given.

The effect of brick arches on the amount of smoke given out by a locomotive in regular operation was most carefully studied, and the writer of the bulletin states that all of the reports of tests with brick arches, as compared with no arch, have been most favorable to their use. "Whether their use is economical or not, provided their expense is not so great that it would be prohibitive, should not stand in the way of their adoption, for they are efficient as smoke preventers. Many tests have been made to determine the value of arches in the saving of fuel. Among these a series of very comprehensive tests has recently been made by the Lake Shore & Michigan Southern Railway. In this investigation a very careful record was kept of the fuel used, the miles run and the tonnage hauled, together with all expenses incident to the arches. Four engines were used in the tests, each one running on the same train for ten days without the arch and ten days with the arch. The results given in the following table show a very gratifying saving of fuel, which amounts to approximately 9 percent. The net saving in dollars and cents per thousand miles varies from $2.58 to $4.89, or an average of $3.44.

Prof. Ringleman's method for classifying the smoke into six grades according to its density or percentage of blackness is the one most commonly used in observations of this kind. This method is explained as follows: In making observations of the smoke proceeding from a chimney, four cards ruled with different thicknesses of lines, together with a card printed in solid black and another left entirely white, are placed in a horizontal row and hung at a point about 50 feet from the observer and as nearly as convenient in line with the chimney. At this distance the lines become invisible, and the cards appear to be of different shades of gray, ranging from very light gray to almost black. The observer glances from the smoke coming from the chimney to the cards, which are numbered from 0 to 5, determines which card most nearly corresponds with the color of the smoke, and makes a record accordingly, at once noting the time.

The width of the lines and area of the spaces are so arranged that the black covers, respectively, 0 percent, 20 percent, 40 percent, 60 percent, 80 percent and 100 percent of the white surface of the card. This is graded for convenience into 0, 1, 2, 3, 4 and 5. By this means, for example, smoke proceeding from the stack which corresponds to card 3 is 60 percent black. Readings of the smoke on these observations were taken every 15 seconds during the time of each run.

IS THE FIREBRICK ARCH, IN LOCOMOTIVES BURNING BITUMINOUS COAL, AN ADJUNCT IN STEAM-MAKING AND ECONOMY?*

Firebrick has been used in locomotive fire-boxes for the

* From a paper read before the Northern Railway Club by Mr. Chas. Cotter, traveling engineer, Duluth and Iron Range Railroad.

COMPARATIVE BRICK-ARCH TEST.

	No Arch.	Arch.	No Arch.	Arch.	No Arch.	Arch.	No Arch.	Arch.
Engine number	4,676.		4,664.		4,668.		4,650.	
Duration of test	10 days	10 days	10 days	10 days	10 days	10 days	10 days	10 days
Train numbers	10 & 5	10 & 5	28 & 23	28 & 23	37 & 4	37 & 4	50 & 3	50 & 3
Average number of cars per trip	9.1	9.2	8.8	8.9	6.2	6.9	5.3	5.3
Average tonnage per trip	479.5	495.8	457.5	459.9	299.3	311.5	226.8	228.0
Total number of miles	2,680	2,680	2,680	2,680	2,680	2,680	2,770	2,770
Total number of ton miles	1,285,060	1,328,744	1,226,100	1,230,120	802,164	834,820	628,236	617,710
Total tons coal consumed	130.5	118.7	140.2	129.6	119.8	110.9	111.2	100.6
Pounds coal consumed, 1,000-ton mile	203	181	228	210	298	265	353	325
Cost coal consumed, 1,000-ton mile	$0.179	$0.159	$0.200	$0.184	$0.262	$0.232	$0.310	$0.286
Average steam pressure per square inch	196.6	198.3	190.3	196.6	194.1	196.5	195.5	197.2
Number of times flues cleaned	15	6	19	9	17	12	16	10
Total cost of cleaning flues	$0.43	$0.21	$0.71	$0.31	$0.59	$0.18	$0.56	$0.21
Number of times netting cleaned	16	7	19	9	18	10	18	10
Total cost of cleaning netting	$0.37	$0.11	$0.58	$0.23	$0.46	$0.24	$0.40	$0.21
Material and labor cost, installing first arch	0.00	8.36	0.00	8.36	0.00	8.36	0.00	8.36
Cost of materials for replacing broken brick	0.00	0.00	0.00	0.70	0.00	1.44	0.00	0.74
Cost of labor for above replacement	0.00	0.00	0.00	0.08	0.00	0.12	0.00	0.06
Cost of material for replacement on account flue work	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cost of labor for above replacement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number of times brick cleaned off	0	0	0	0	0	0	0	0
Total cost of cleaning brick	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total cost for maintenance per 1,000 miles	0.00	3.10	0.00	3.41	0.00	3.66	0.00	3.30
Gross amount saved by use of arch over no arch, 1,000 miles	0.00	7.99	0.00	7.16	0.00	8.20	0.00	5.88
Net amount saved by use of arch over no arch, 1,000 miles	0.00	4.89	0.00	3.75	0.00	4.55	0.00	2.58

past fifty-one years, not always in the form of an arch, but for the same purpose. During this time many other coal-saving devices have been put on locomotives and have long since gone out of existence, but the brick arch is still retained by many of the leading railroads, which should be a sufficient guarantee of its efficiency.

Firebrick are usually made in the form of an arch, as the name implies, and are supported by lugs screwed into the side sheets, or supported by arch tubes fastened into the flue and back sheets in such a way as to permit a circulation of water through them. Usually a space of about six inches is left between the flue sheet and front part of the arch, to allow room for coal to drop through, thus preventing the filling-up on top of the arch. The arch should be sealed to the side sheets. The front part should be from 1 to 8 inches below the bottom flues. This distance, however, depends on the depth of the fire-box, but, in no case, should the space from the grate to the center of arch nearest the flue sheet be less than 14 inches. The opening between the back part of the arch and the crown sheet ought not to be less than 18 inches. The arch should cover about 50 percent of the grate area.

With the hollow arch there are holes through each side of the front part of the fire-box, which registers with the openings in the arch, so that the air is drawn through the arch and is discharged in a downward angle at the back end of it. It is claimed that the air, in passing through the arch, is heated to the igniting temperature, so that when it is discharged into the fire-box it readily mixes with the gases discharged from the coal and makes a more perfect combustion.

The burning of bituminous coal is a very complex operation. The volatile gases, in this kind of coal, contain great heat generating power, but they are difficult to burn so that none of the heating elements will be lost.

The average bituminous coal contains 65 percent of carbon and 25 percent of hydrogen. About one-fourth, by weight, of the latter is hydrogen-gas, which makes the hottest fire that can be burned; but it ignites only at a very high temperature, and, if the fire-box or any part of it gets cooler than this, all or a part of the gas passes away unconsumed. In that case there is a direct loss by the gas not being used to create heat, and also a loss of the heat used in distilling those gases from the burning coal.

The combustion of each pound of hydrogen-gas, if it is combined with 8 pounds of oxygen taken from the air, produces about 62,000 heat units, while each pound of carbon requires only 2 2/3 pounds of oxygen and produces only about 14,500 heat units; so that while the percent of hydrogen-gas in the coal is low, its heat-making qualities are more than 4 to 1.

The advantages of the brick arch are: You can burn a whiter fire, because gases are delayed longer, allowing oxygen more time to mix with the hydrocarbon in the coal, enabling the development of a more perfect combustion.

The brick arch increases the temperature of the fire-box, because of the high temperature of the brick itself, which forms a better combustion chamber than the relatively colder surface of the fire-box sheets. The higher temperature results in the production of a smaller proportion of carbonic-oxide.

Tests made by the Pennsylvania Railroad have shown that a fire-box with a brick arch will average about 220 degrees more heat than one without it. The burning of the gases, which can be done effectually only by the use of the arch, reduces the smoke nuisance.

The brick arch is a most efficient device for the reduction of the quantity of sparks thrown from the stack. It increases the length of the flameway, and the finer fuel, when lifted from the grates, is held in suspension in the gases, and most of it consumed, instead of passing directly to the flues and out of the stack in the form of sparks.

It has been determined by Prof. Goss, on the Purdue Locomotive Testing Plant, that a locomotive, working under the common practice of to-day, may draw through the flues, in the form of front end cinders or sparks, equivalent to from 11 to 16 percent of the fuel fired.

The arch maintains a more even temperature in the flues, preventing, to a great extent, an unequal expansion and contraction, thereby increasing the life of the flues.

The arch catches the pasty substance that forms honeycomb and thus prevents the flues from stopping up. Stopped-up flues will soon cause them to leak, on account of the unequal expansion and contraction. For instance, the flues that are stopped up are hotter on the outside than on the inside, while the flues that are opened are hotter on the inside than on the outside, and thus we have the stopped-up flues pulling on the flue sheet while those that are opened are pushing on it, and we know that flues will not remain tight any great length of time under those conditions. Stopped-up flues reduce the heating surface.

Last fall, during the last three months of the ore season on the Duluth & Iron Range, we had but little or no flue work done on account of the boilermakers' trouble. During this time those engines that were equipped with the arch gave us but little trouble when compared with engines without one,—notwithstanding we had honeycomb bars placed at water tanks, on the line of the road about 35 miles apart, for the purpose of scraping off the honeycomb, and it was nothing unusual to find 50 or 60 flues coated over at those points on engines having no arch.

In the early days of the Northern Pacific (before arches were used there) I was pulling a passenger train on the Dakota division, between Fargo and Bismarck. In those days the engines were small, the water was bad and the winds were usually high. In trying to make time against a heavy northwest wind, while going west, the flues would almost invariably start leaking, but, after the arches were put in, those leaky flues were almost entirely eliminated. It is a fact that there is a saving to the flues caused by the arch, for, when the fire-box door is opened, the inrushing air must first come in contact with the hot arch and thereby becomes heated before it strikes the flue sheet.

On the Duluth & Iron Range we have always found it necessary to reduce the nozzle tip when, for any reason, the arch was removed from our passenger engines, and, in such cases, those engines without the arch, in making a round trip of 234 miles, would burn about 1½ tons of coal more than they did before the arch was removed.

A lighter fire can be carried with than without the arch. This is especially so where the work of the engine is constantly fluctuating between its maximum power and no work at all, because the firebrick retain so much heat that it is not necessary to put in a heavy charge of coal just before starting to use steam, and, with the light fire, a longer run can be made without cleaning fire; besides, the fireman is assured of a good steaming engine on the last part of the run, providing the engine is properly fired.

I have no ton-mile report to show what a locomotive equipped with the arch will save in coal over one of the same class without it. The following is a ton-mile statement, showing comparative tests of the solid arch and the Wade-Nicholson hollow arch on engine 72 of the Duluth & Iron Range:

THE DULUTH & IRON RANGE RAILROAD COMPANY. OFFICE SUPERINTENDENT MOTIVE POWER.

Statement showing comparative tests of the solid arch and the Wade-Nicholson hollow brick arch, on engine No. 72, July 17, Aug. 12, 13, 14, 15 and 16, 1907.

All trips made between Two Harbors and Fayal, with exception of one trip, at which time train turned at Biwabik.

Kind Arch.	Date, 1907.	Tons Coal Consumed.	Miles Run.	Ton Miles.	Tons Hauled One Mile Per Ton Coal.
Solid	Aug. 16	10.7	147	187,640	17,753.5
Hollow ...	July 17	7.9	147	154,692	19,581.2
Hollow ..	Aug. 12	10.9	147	195,438	17,930.2
Hollow ...	Aug. 13	9.6	147	179,148	18,661.2
Solid	Aug. 14	10.5	147	180,707	17,210.2
Solid	Aug. 15	8.5	123	139,548	16,417.4

Average tons hauled 1 mile per ton of coal with hollow arch, 18,724.2.

Average tons hauled 1 mile per ton of coal with solid arch, 17,127.2.

Average saving in fuel with hollow arch, .0932 percent.

This hollow arch was in service about three months.

Combustion holes in side of fire-box were plugged to make the solid arch.

Both the American Railway Master Mechanics and the Master Steam Boiler Makers' Associations are on record as favoring the brick arch, where conditions are favorable. Of course, there are cases where a brick arch could not be used with any degree of economy; that is, in districts where the water is very bad and where flues are so weak that it is necessary to calk them every trip or two.

THE USE AND ABUSE OF FIREBRICK FOR LOCOMOTIVE FIRE-BOXES.

BY J. E. BOND.

Firebrick arches have been used for so many years in locomotive fire-boxes that the purchasing departments and motive power departments of the railroads, as well as the manufacturers of firebrick for this purpose, seem to have fallen into a rut, and apparently the subject is not receiving the attention it deserves. In the opinion of the writer there is room for improvement in both the manufacture and use of firebrick arches.

Cold air after extreme heat is the hardest test of a good firebrick. It is a regular occurrence, on most roads, to run an engine over the ash-pit at the end of a run, turn on the blower and knock out all the fire. The cold air striking the red-hot bricks cools the outside, and, unless properly made, the bricks crack and are destroyed. Experience has shown the writer that a firebrick can be made by any of the larger manufacturers that will increase the life of the arch an average of 100 percent; that is, while on most roads the firebrick arch lasts from ten days to two weeks, by giving proper attention to the design and mixture of the clay, the average life could be increased to from twenty days to a month.

Manufacturers generally have an idea that the vibration of the locomotive is a great factor in the destruction of the arch, and that a tile must be made of such a mixture as will give as great physical strength as possible. As a matter of fact, vibration is a small factor in the destruction of the arch. The writer realizes that each clay requires a peculiar treatment of its own to get the best results; that a method of handling the clay in a given district would not be successful with another clay, even a few miles distant. Therefore, it is impossible to have a specific rule that will apply to all clays, but there are certain general details that apply to the manufacture of all firebrick.

For the benefit of those not familiar with the subject, a brief description of the process will be given. Fire-clay usually occurs under coal measures, and is virtually a pure clay. The chemical analysis is of great importance in certain lines of work; it is of less importance in railroad work than the physical qualities, since the gases of coal do not cause much deterioration, unless there is a considerable percentage of iron in the clay, when the sulphur of the coal may unite with the iron pyrites and cause injury to the brick. Fire-clay is mined about the same as coal. When it first comes from the mine it is as hard as stone, and fractures of the clay will be so sharp that the pieces will cut the hands. The clay is of three general varieties: plastic, semi-plastic and flint. The first, when tempered, becomes like putty, and is easily worked with the hand. The second, if exposed to the weather sufficiently, or if sufficiently tempered, will also become plastic. The flint clay will not become plastic when exposed to weather, but will break up into small crystals if exposed for some time. The chemical analysis of these three clays may be identical. The clays are ordinarily pulverized in a dry-pan crusher, and mixed with calcine (burned fire-clay) ready for tempering. The tempering is ordinarily done in a wet pan. The clay is taken from the wet pan to the moulders, where it is moulded into the desired shapes by hand. It is then placed on a hot floor, where it is dried, and afterwards burned in a kiln at a temperature of about 3,000 degrees F., after which it is allowed to cool down slowly for a number of days before opening the kiln.

Now, it is the mixture of the clay that determines the character of the brick. For high grade, such as is used in blast furnaces, steel furnaces, etc., the mixture is largely flint and calcine, with just enough plastic clay to form a bond to unite the particles. It is made in as soft mud as will retain its shape after being moulded. When this is dry it is exceedingly porous, and is not physically strong. It is nearly white in color after burning, and when fractured can be pulled apart by the fingers in many cases. However, when this brick is subjected to high heat and sudden changes of temperature it does not crack or check, because its porosity enables it to cool more uniformly throughout its mass. The expansion and contraction is also much less than in the more plastic kinds of brick. High-grade bricks will not answer for all purposes, since they are too easily injured by abrasion. For instance, in the top of a blast furnace, where the charging of the furnace would destroy high-grade brick, it is necessary to use more plastic clay and less flint.

A great deal of study has been given by iron and steel makers, as well as by manufacturers of firebrick, to get up a material exactly suited to each process connected with the art. It is not advisable to make locomotive tiles of the same mixture as high-grade brick, because they would not have sufficient strength to get them into the fire-boxes; but the mixture should approach nearer to the high grade than that which is generally supplied to railroads. Now, the higher the proportion of flint clays and calcined clay used up to the point that will be bound together, the greater the heat and the variations of temperature the brick will stand, but the more delicate the brick will be to handle cold. Conversely, the greater the proportion of plastic clays used in the mixture, the less change of temperature it will stand, but the stronger physically the brick will be while cold. It is not altogether the fault of the manufacturer that he makes his mixture too low a grade to stand the changes of temperature incident to the locomotive operation. It costs him no more, ordinarily, to make a high-grade than a low-grade brick, but the designs submitted will not stand up in the higher grade material. It is, therefore, up to the railroads to design a brick that will stand.

But it is impossible for a designer who is not familiar with the process of manufacture to design firebrick intelligently. It would be money well spent to send the designing engineer to the firebrick factories to spend as long a time as he needs to get an insight into the business, and that he may co-operate with the manufacturer in getting out designs that can be made. As a case in point, a manufacturer of firebrick in Missouri showed the writer a design from a prominent western road that called for iron bars in the tiles to strengthen them. They ran the entire length of the arch. This manufacturer simply made holes through the tiles, which were for wide fire-box engines, and told the railroad people they could supply their own iron. For it is well known by all who are familiar with the art that iron heated to the temperature of the fire-box has little or no strength, even if it is not melted, and had the iron been placed in the tiles before burning, it would have been melted long before the furnace attained the heat necessary to burn the brick, and would have ruined any other bricks in the kiln as well.

Most roads make tiles for wide fire-box engines in two sections, butting the tiles together in the middle of the fire-box. This the writer believes to be wrong in principle where arch tubes are used. There are usually four tubes to support the tiles. The joints should be made over the tubes in order that there be as little overhang or cantilever as possible. Now, because the tubes, containing water, keep the adjacent part of the tile cooler than the part which is away from the tube, this causes the material to expand on the top of the tile, and remain contracted on the lower side, causing the tile to droop and gradually to fracture. Then when a rough place is produced by the drooping of the tile, the action of the gases and cinders becomes much greater at this point, causing more rapid abrasion. In narrower types of fire-boxes containing two tubes it is better to make a joint over each tube, with a special tile supported on studs in the side sheets for the ends; or make the end tile longer, so that the end resting on the tube is lower than the end resting against the side sheets. The studs can thus be dispensed with.

The writer has seen large quantities of firebrick arches stored in the open air on certain roads in the West and Northwest. Nothing could be worse for firebrick of a quality good enough to stand the changes of temperature than exposure to winter weather, for the reason that a good firebrick is exceedingly porous and absorbs a great deal of water. When the water freezes it expands and fractures, if it does not break, the brick. It is economy to erect good dry storage sheds for all firebrick. Even the moisture absorbed from the atmosphere makes a brick more delicate in cold weather. Summer rains are not so injurious as the winter rains.

Complaint came to the writer that a certain road was having heavy loss in its locomotive tile. It was high-grade material and should have yielded good results. Investigation revealed the fact that the tiles were piled 20 to 25 feet high in a shed. It was being handled by cheap help, and indeed the breakage was a serious item. Manufacturers seldom, if ever, pile firebrick to exceed 8 feet high, because it is not strong enough to withstand the pressure incident to higher piling, especially in the winter, when frost weakens the material.

Another abuse often seen is to bring tiles covered with ice into the roundhouse; install them in a fire-box and then build a fire under the arch with forced draft. The unequal expansion is sure to cause injury to any firebrick under such circumstances, and very often the arch will break down before the engine reaches her train.

The higher the grade of brick, the better it will stand this kind of abuse, since the greater porosity enables the steam to escape more readily, but it will be much better to store the bricks in a warm place for a few days before installing, in order that they may become as dry as possible. In starting up a new stove or blast furnace, steel manufacturers take several days to get their furnaces up to heat, but they expect to get months or even years of service out of a lining.

Intelligent study of the subject will, without doubt, reduce expense in the use of firebrick arches.—*The Railroad Gazette.*

Every foreman boiler maker should attend the annual convention of the International Master Boiler Makers' Association at Louisville, Ky., April 27, 28, 29 and 30.

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An Association of Boiler Inspectors.

It has recently been suggested by the chief boiler inspector in one of our large cities that it would be a very beneficial thing if a national association should be formed by the boiler inspection departments of all States and cities where laws are now in force governing the construction and inspection of steam boilers. The primary object of this association would be the formulating of a uniform standard for boiler construction throughout the United States. The trend of modern economics is strongly towards standardization. The buyer of apparatus of nearly every class has been educated to rely on the assumption that whatever he buys, from a cap screw to a locomotive, is up to a fixed standard, but, in the matter of steam boilers, there seems to be a lamentable lack of uniformity both in design and quality of materials. Furthermore, it is common practice under municipal inspection to first install a boiler and then depend on securing its acceptance and approval. This method naturally tends to compromises that do not promote public safety nor the interests of the owner of the boiler. Undoubtedly an organization of boiler inspectors, such as has been suggested, would do a great work toward educating the public to an acceptance of a uniform standard, simply because it is the inspectors who must watch the enforcement of a standard.

At present it is difficult even to get an accurate list of cities which have adequate boiler inspection laws, and, as the first step toward the formation of such an organization involves the necessity not only of obtaining such a list, but also copies of the regulations in force, and expressions of opinion on the project from the inspectors themselves, we would be glad to have any of our readers send us not only the names of cities where they have some knowledge of the boiler inspection laws, but also, if possible, to send us copies of those laws and a personal expression of their opinion regarding the value of the proposed organization.

Inspection of Locomotive Boilers.

A recent press dispatch states that a conference has been held with labor leaders in the office of the Secretary of Commerce and Labor, the object of which was to make effective one of the recommendations of the recent labor conference called by the Secretary. It was decided that a bill be drafted, for submission to Congress, providing that locomotive boilers should have the same kind of inspection as the government requires of marine boilers. Commenting on this question in his annual report, Secretary Straus stated: "In considering the appalling loss of life by railway accidents in the last calendar year, and in looking over possible methods of prevention used, one is indeed forced to feel that a great advance ought to result therein by the extension of the work of the service to an inspection of locomotive boilers and equipment."

We fail to see how government inspection of locomotive boilers would tend to reduce the appalling loss of life due to railroad accidents. The boilers of locomotives are, as a rule, more carefully inspected and better cared for than any other boilers in operation in the United States. It is a rare thing for a locomotive boiler explosion to result in an "appalling loss of life." When a serious accident does occur, it is in nine cases out of ten the fault of the engineer, who permits the water to get low in the boiler, rather than any lack of care in the construction and inspection of the boiler itself.

If federal inspection is to be extended to any other boilers than marine boilers, it should include first of all stationary boilers. This is an object which boiler manufacturers and engineers have been seeking to accomplish for a good many years, and one which would undoubtedly tend to reduce the great loss of life which is yearly credited to boiler explosions, and which is greater than that due to mine explosions, which the government is now making every effort to minimize.

Improved Shop Tools.

We invite particular attention this month to our leading article, which describes a number of improved shop tools which are in use in the Southern Pacific shops at Los Angeles, Cal. This article will be followed by others from the same source in succeeding issues, and by the publication of these articles we hope to do two things: first, arouse interest in the development of original ideas for carrying out with greater ease, rapidity and economy shop operations, which have come to be considered by many unchangable; and, second, to encourage the publication and exchange of such ideas among our readers. The Southern Pacific shops are not the only place where men with progressive ideas are at work, and we hope that others will soon be heard from.

A LARGE WAREHOUSE FOR BOILER MAKERS' SUPPLIES

Large new offices and warehouses have been erected by Joseph T. Ryerson & Son, at the corner of Sixteenth and Rockwell streets, Chicago. These buildings cover 750,000 square feet of floor space, giving storage and handling facilities for 150,000 tons of material, affording the steel consumer a stock source of supply not only greater than the combined warehouse stock of any other city in the United States, but greater than the combined stocks of any other three cities in America.

The structural steel warehouse, comprising over 8 acres of floor space, is divided into bays each 500 feet long and varying in width from 45 to 110 feet. All buildings are of steel construction throughout, and the roofs are corrugated iron and glass. Three railroad switch tracks enter these buildings and extend along the entire east end, furnishing accommodations under roof for forty-nine cars at one time. The crane service operating in each bay, over and at right angles to the railroad tracks, affords every desirable facility for loading and unloading. The railroad shipping facilities are supplemented by two wide wagon driveways, which, like the switch tracks, are accessible to the entire warehouse crane service. There are eight high-speed traveling bridge cranes and two radial wall jib cranes in this department, in addition to the complete roller tables and hoisting systems used in connection with the various machinery equipment. Of the above-mentioned cranes four are of 100 feet span and 10 tons capacity. Each is equipped with two trolleys and operated from a stationary cage. These cranes have a bridge traveling speed of 350 feet per minute, and a trolley traveling speed of 175 feet per minute.

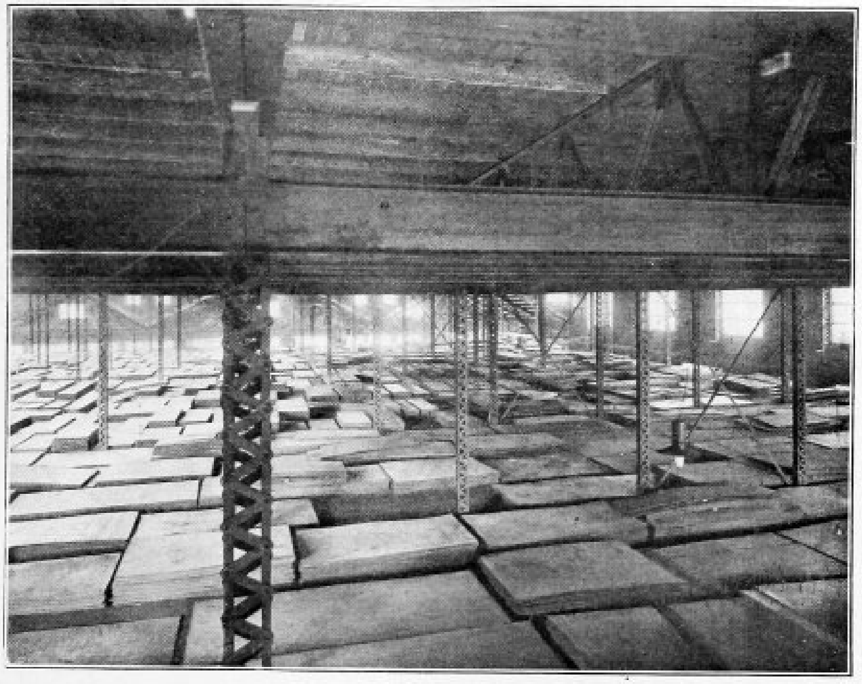


FIG. 1.—ONE END OF THE FLOOR DEVOTED TO THE STORAGE OF BOILER PLATES.

A feature of this department is the equipment for the rapid cutting of structural material. In addition to angle shears, plate shears, etc., there are installed three high-speed friction saws, each machine consisting of a steel holding carriage, hydraulically driven forward and backward in V-shaped grooves on a structural steel and cement foundation. The saw blades are 52 inches in diameter, and are motor-driven at a peripheral speed of 27,000 feet a minute. A 24-inch, 100-pound beam can be cut in less than twenty seconds. These machines are fed by roller tables, which carry the material up to a position where it is reached by the forward motion of the saw.

FIG. 2.—A BIRD'S-EYE VIEW OF THE WAREHOUSES.

The stock of sheet steel is carried in a heated and artificiallyventilated room, comprising 30,000 square feet of floor space. The sheets are arranged in piles according to size, each size of each gage being given a separate sub-division of the floor. For the convenience of the sheet metal worker, who is not supplied with shearing facilities, there are installed three heavy motor-driven guillotine shears, each capable of splitting the widest sheet rolled. The entire floor is served by traveling cranes, so arranged that sheets may be picked up from any part of the floor and loaded directly on to the cars or wagons. The cranes are also accessible to the large shears, corrugating machines and other equipment.

Directly east of the office building, and separated from it by the loading driveway with two crane runways above, is the plate and bar warehouse. This building is of heavy steel, two-story construction, and provides for 140,000 square feet of storage space. The crane floor is arranged in aisles for the accommodation of the 740 different sizes of iron and steel bars and bands.

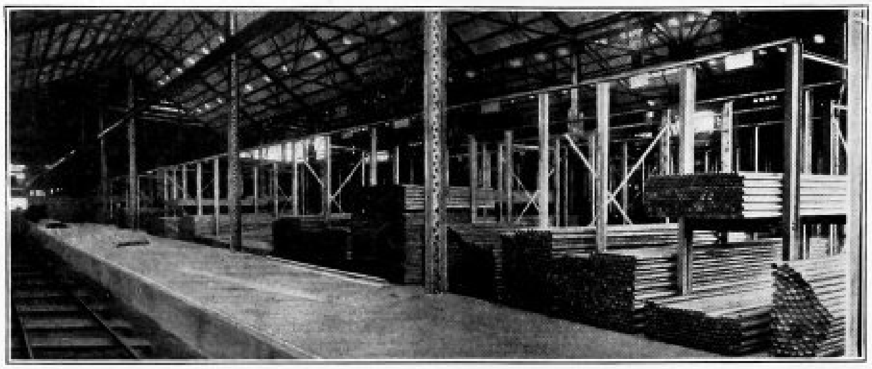


FIG. 3.—BOILER TUBES ARE STORED IN SPECIAL STEEL RACKS.

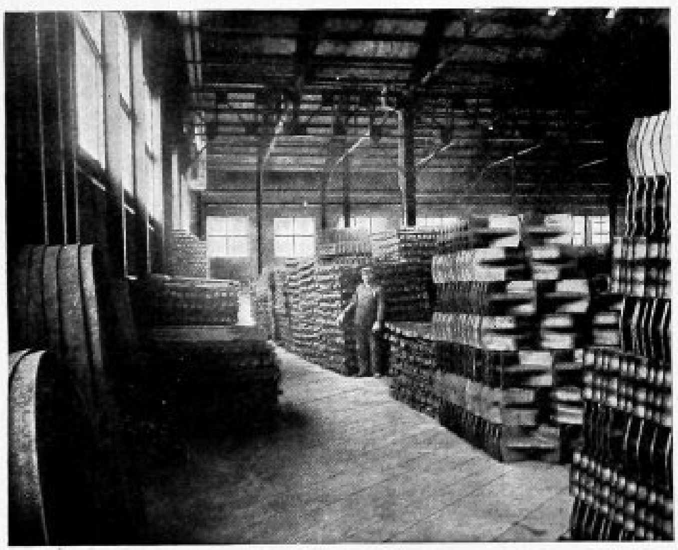


FIG. 4.—THE STORAGE SPACE FOR BOILER HEADS, LUGS AND MANHOLES.

The second floor of the building is assigned entirely to the storage of over 600 different sizes of plate stock. The plates are laid flat on the floor to prevent distortion. Each size is located in a separate pile and arranged in bays according to grade and thickness.

The shipping facilities of this building are of more than ordinary interest. The plate floor, instead of being carried to the east building wall, permits of a double crane runway, which extends along the entire length of the east side of the structure, similar to that extending along the west end. These cranes are all of 10-ton capacity, and so designed that the carriages can run off the crane bridges proper and on to the I-beam trolley system which serves the entire storage floors. Beneath the east crane runways there is a switch track and beneath the west a wagon driveway; thus any portion of the warehouse may be reached by cranes, which may carry their loads to or from the cars, wagons or shearing machinery without a single transfer. Adjoining that portion of the warehouse particularly devoted to boiler specialties is the storeroom for boiler and tank heads, circles, etc. Here may be found not only the plain heads in flanged and tank steel, but also dished and flanged heads of various types and sizes for boiler construction, as well as tubes, rivets, braces, lugs, hangers and manholes.

Boiler tubes are stored in specially built structural steel racks, the various qualities and types, such as seamless steel, lap-weld steel, charcoal iron, etc., each being given different sections of the floor, while each size and length of tube is given a separate compartment. Motor-driven tube cutting machines are located convenient to each section, so that tubes may be furnished in special lengths, while in connection with the tube stock are a great number of all allied specialties, such as expanders, pneumatic and hand cutters, flue-cleaning machinery, flue plugs, copper ferrules, etc., as well as other machinery, fittings and material needed in boiler construction and repair.

PERSONAL.

L. M. STEWART has been transferred from Sanford, Fla., to Waycross, Ga., as general foreman boiler maker of the new shops recently erected by the Atlantic Coast Line.

R. E. HOWE has recently taken the position as foreman boiler maker with the Rutland Railroad Company, at Rutland, Vt. Mr. Howe was formerly connected with the American Locomotive Company, Schenectady, N. Y.

WILLIAM HENRY, formerly boiler maker at the Canadian Pacific Railway shops at Winnipeg, has been promoted to foreman boiler maker Canadian Pacific Railway shops at Vancouver, B. C., Can.

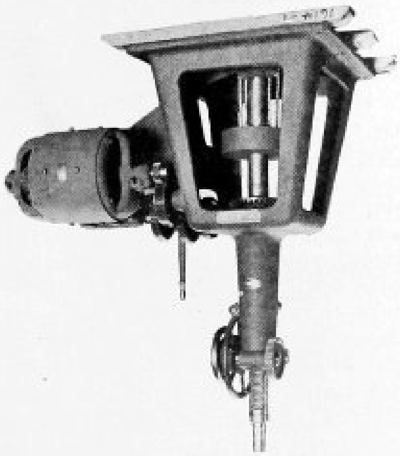
FRANK RUSCH has been appointed master mechanic of the Chicago, Milwaukee & St. Paul lines, west of Butte at Seattle, Wash.

JOE HOLLOWAY, formerly constructing engineer of the Mason Smokeless Combustion Company, at Los Angeles, Cal., has accepted the position of chief engineer of the American Petroleum Company, Santa Monica, Cal.

ENGINEERING SPECIALTIES.

A Motor-driven Suspended Drilling Machine.

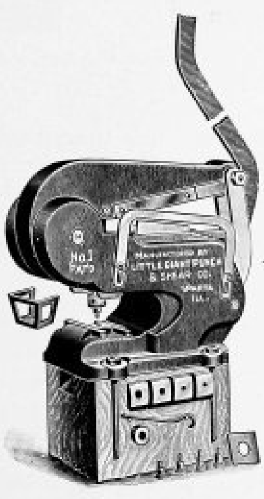
This machine is intended to be attached to the ceiling or overhead framing, leaving the space below entirely clear, so that boiler sheets or other large work can be easily drilled. The machine has a spindle 2 inches in diameter, with a 12-inch traverse, and hand feeds; it is not back geared. The



machine is driven by a 5-horsepower General Electric motor mounted on the frame and geared direct, giving a range of spindle speeds from 18 to 172 revolutions per minute. A larger size, which has a 2⅝-inch spindle and 20-inch traverse, with hand and power feeds, is also built. This is back-geared and has quick hand movement. The manufacturers are the Niles-Bement-Pond Company, 111 Broadway, N. Y.

A Little Giant Combined Punch and Shear.

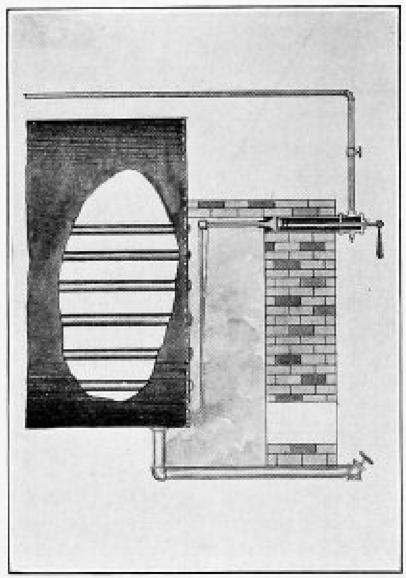
An efficient punch and shear for light work has been placed on the market by the Little Giant Punch & Shear Company, Sparta, Ill. The machine is operated by hand by means of a lever, and is made in sizes capable of punching ⅝-inch holes in ½-inch iron and cutting flat bars ⅝ inch by 2½ inches.



The largest size machines weigh 515 pounds, and occupy a floor space 12 by 26 inches. The upper shear has reversible cutting edges, and is held in place by two bolts. There are two lower shears, one for round and one for flat iron, held in a groove by means of a key. They are also reversible, so that all four edges can be used before redressing. The dies for punching are made with beveled edges and are crowned on top. They are held in place in the same manner as the lower shears. The punches, which are of extra special tool steel, properly tempered, are held in place by a lock nut. As shown in the illustration, two lugs are provided for holding the stripper, which, being slightly tapered, slides into its place as a dovetail, and, therefore, requires no bolts or other fastenings. By means of an improved holding-down device the machine is particularly convenient for cutting short pieces of iron, and only one man is needed for the job, where formerly two were required. The lever is about 8 feet long, so that a powerful stroke can be given the machine.

The United States Tube Blower.

This is a device operating from the rear end of return-tubular boilers, which blows the soot out of the tubes with the draft and up the stack. A casting passes through the rear boiler wall, and a T-shaped cast chamber outside the wall receives a 1½-inch supply pipe. Directly under the pipe in the chamber there is a drain cock to dispose of the condensation. On the end of this chamber is a stuffing-box, through which the handle rod passes to an inner tube which just fills the casting through the wall. On the end of this tube is a hollow



cast-iron arm, one-half the diameter of the boiler in length, and which has, on the side towards the boiler, a slot cut the entire length, 1/16 inch in width. By pushing the rod endwise the tube is pushed forward, so the slotted arm is close to the rear end of the tubes, into which the steam is delivered in a thin sheet with a velocity depending on its pressure. By means of a handle secured to a rod the arm may be revolved so it reaches all of the tubes.

This blower can be used while running as many times a day as necessary to keep the tubes perfectly clean, and when not in use the arm is pulled back and laid in a horizontal position on a shelf, where it is not exposed to the heat. It is claimed that the blower effects a saving of at least 25 percent in fuel, besides a great amount of hard work on the part of the firemen. All connections are metallic, so there is no hose to burst and scald the operator. The blower is manufactured by the United States Specialty Manufacturing Company, Pittsburg, Pa.

A Handy Magnet.

Something new in the lifting magnet line has just been placed on the market by the Cutler-Hammer Clutch Company, of Milwaukee, Wis., whose large lifting magnets are widely used in the iron and steel industries for handling pig iron, scrap, etc. The new device is a hand magnet weighing only about 7 pounds, but capable of lifting castings of from ten to fifteen times its own weight. The magnet is designed for operation on 110-volt, direct-current circuits, and is furnished with a drop-cord and attachment plug, so that it may be readily attached to any ordinary lamp socket. The push-button mounted on top of the magnet, and operated by the

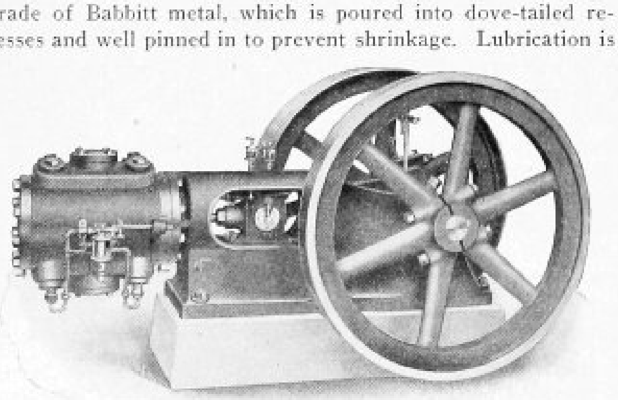
thumb, closes the circuit to the coils and makes the magnet operative. On releasing the button the poles become demagnetized and the load is released.

This magnet seems to be capable of many useful applications. In machine shops it is used for clearing chips and borings out of the machinery, or removing them from parts of the work not easily accessible. Dropped tools, bolts, boring bars, etc., are easily recovered with the aid of the magnet from places from which it would be difficult to fish them by ordinary means. In foundries it may be used to pick up hot or awkwardly shaped castings, smooth plates, which are sometimes difficult to secure a hold on when laying on a flat surface, or for cleansing the molding sand of minute particles of metal.

Dallett Air Compressors.

A line of air compressors built by Thos. H. Dallett & Company, Philadelphia, Pa., shows many excellent and unique ideas in design. These compressors are designed so that all parts requiring adjustment or renewal are readily accessible, and by using a liberal amount of metal, rigidity in operation is insured. The capacity of any compressor may be increased by replacing its air cylinder by that of its next larger size.

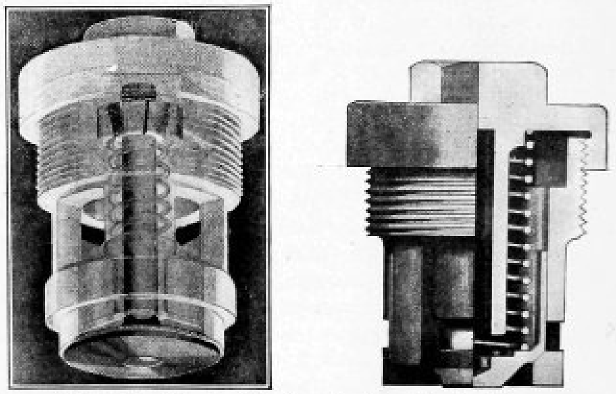
The frame is of the open-fork center crank type. The duplex belt, duplex steam and single steam machines are supported on a deep, rigid sub-base, thus making the entire machine self-contained. The main bearings are lined with a high grade of Babbitt metal, which is poured into dove-tailed recesses and well pinned in to prevent shrinkage. Lubrication is



effected by sight-feed devices, gravity or a force-feed system, drainage being provided for all drips from the guides, stuffing-boxes and the crank pit.

The steam cylinder and valve gear of the steam-driven machines are well suited to the operation of compressors, giving high efficiency with little attention. The clearance has been reduced to a minimum. A plain *D* balanced slide valve is used on the small and medium-sized machines, while the Meyer balanced, adjustable, cut-off valve is used on the large machines. The rocker arms on all valve gears are adjustable to compensate for wear. On the steam-driven machines, the governor is equipped with a safety-stop device, which stops the machine on a breaking of the governor belt. The governor pulley is placed on the end of the shaft outside of the fly-wheel on the single machine, thus bringing the fly-wheel as close to the bearings as possible, and also preventing oil or grease, thrown by the eccentric, from getting on the governor belt. A reducing valve is used on the duplex compressors with compound steam cylinders, which reduces the live steam pressure for use in the low-pressure cylinder. If the high-pressure side stops on the dead center, live steam is fed to the low-pressure cylinder through the reducing valve for starting. The live steam is taken into the low-pressure side only when starting, otherwise the operation is identical with any compound machine.

The air cylinders are of special hard, close-grained iron, and each is thoroughly tested under hydraulic pressure of 200 pounds before assembling. The clearance space is reduced to a minimum, and all heads and cylinder walls are thoroughly



water-jacketed. Oil is fed directly into the intake passage, and the suction carries it into the cylinder in the form of a fine spray.

The cross head is a new type box pattern, made of semi-steel. The shoes are adjustable and have large bearing surfaces. The upper shoe is lubricated by a sight-feed lubricator, and the lower one runs in oil. One of the features of this design is the side openings, which allow easy access to the binder nuts. The intake valve, of the automatic poppet type, is contained in a malleable iron cage. The cage is one piece, and combines both seat for the valve and guide for the valve stem. The cage is threaded, and screws into the wall of the air-intake chamber only, and is simply seated in a recess on the main cylinder wall. The valve proper is a special alloy hardened steel, with seat and stem ground to gage. The valve spring is of phosphor bronze. To eliminate the shearing off or loosening of valve spring holders, the "Dallett" spring holder comprises a split taper ring set into a recess on the valve stem, and held together by means of a solid taper ring slipping down over it. The hammering of the valve on its seat tends to tighten the spring holder on the stem instead of driving it off. The discharge valve is of the automatic poppet type, contained in a valve cage of malleable iron. The method of seating in the cylinder and locking to its seat is identical with that of the intake valve.

The inter-cooler plays a very important part in the economical operation of a two-stage machine. The "Dallett" inter-cooler employs the return-flow type of water circulation, using baffle plates to deflect the flow of air and in its effectual contact with the cooling tubes. The nest of cooling tubes may be removed intact from the inter-cooler box without disturbing any of the piping, as unions are supplied.

Automatic regulation of the supply of air is secured by an unloading device. When a certain determined pressure is reached in the air receiver, one or more inlet valves are held open, and the load is taken off the compressor, allowing it to run light until the pressure drops in the receiver, upon which the valves are released and air compression is resumed. On the steam machines a combined speed and pressure governor is used.

The Dallett compressors are built in sizes ranging from an 8-inch stroke up to a 16-inch stroke, giving a range of capacity from 79 cubic feet of free air per minute to 1,200 cubic feet.

SELECTED BOILER PATENTS.

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

905,550. OIL-BURNING FURNACE. THOMAS C. MASON, OF LOS ANGELES, CAL., ASSIGNOR, BY MESNE ASSIGNMENTS, TO MASON SMOKELESS COMBUSTION COMPANY, OF CARSON CITY, NEV., A CORPORATION OF NEVADA.

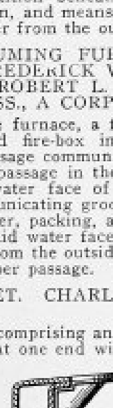
Claim 2.—An oil-burning furnace comprising a combustion chamber, a burner chamber at the front end of said combustion chamber, a rearwardly directed burner in said burner chamber, the floor of the burner chamber having openings therein to supply air, deflectors at the sides of the burner chamber, a partition beneath said openings, an air inlet chamber beneath the partition, and means for controlling the passage of air into said air inlet chamber from the outside. Three claims.

905,321. SMOKE-CONSUMING FURNACE. HARRY A. JACKSON, OF LYNN, AND FREDERICK W. ROBERTS, OF BOSTON, MASS., ASSIGNORS TO ROBERT L. WALKER FURNACE COMPANY, OF BOSTON, MASS., A CORPORATION OF MAINE.

Claim 2.—In a locomotive furnace, a fire-box provided with a grate, a water leg to divide said fire-box into compartments, a swinging damper having a damper passage communicating with its front pivot and a communicating discharge passage in the damper trunnion, a trunnion box mounted in the rear water face of the boiler and provided with discharge holes and a communicating groove to co-operate with said discharge passage in said damper, packing, and packing glands around said trunnion on both sides of said water face, fastening bolts engaging said glands to tighten the same from the outside of said water face and means to supply water to said damper passage. Seven claims.

908,566. WATER-JACKET. CHARLES W. HAWKES, OF NEW YORK, N. Y.

Claim 1.—A water-jacket comprising an inside and outside sheet, stay-bolts in integral connection at one end with the inside sheet, and means



independent of the stay-bolts for securing the free ends of the latter to the outside sheet. Eleven claims.

908,510. GRATE AND ASH-PIT FOR FURNACES. CHARLES SMITH, OF CHICAGO, ILL., ASSIGNOR TO CHARLES SMITH COMPANY, OF CHICAGO, A CORPORATION OF ILLINOIS.

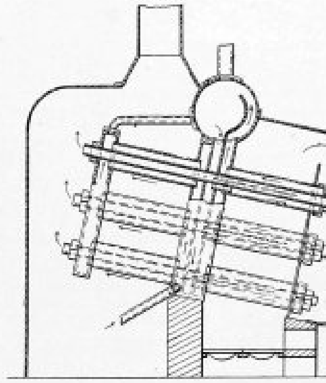
Abstract.—The invention consists in an ash pit having at its inner or rear end a series of separate sockets or bearings to receive the inner or rear ends of a series of independently operative and independently removable grate bars, and provided at its front portion with a grate supporting bar furnished with a plurality of seats or slots, to receive a plurality of independently removable bearing blocks, and movable holders or keepers for holding the removable bearing blocks in place, and a plurality of independently operative and independently removable grate bars. Five claims.

908,565. NOZZLE FOR BOILER-TUBE CLEANERS. RICHARD W. HAMANN, OF ST. LOUIS, MO., ASSIGNOR TO EUGENE J. FEINER, OF ST. LOUIS.

Claim 2.—A nozzle for boiler flue cleaners, comprising a cylinder, in the wall of the body of which is formed a plurality of pairs of discharge apertures, all of which apertures occupy a plane passing lengthwise through the center of the cylinder, and one of the apertures of each pair being larger than the remaining aperture. Ten claims.

908,574. BOILER. HANS O. KEFERSTEIN, OF NEW ORLEANS, LA.

Claim 1.—In a boiler, the combination, with a fire chamber, and a smoke chamber; of fire tubes operatively connecting the said chambers, water tubes encircling the said fire tubes, and arranged in the said



chambers in separate series, and means for circulating the water through the series of water tubes in the said smoke chamber and thence into the series of water tubes in the said fire chamber. Six claims.

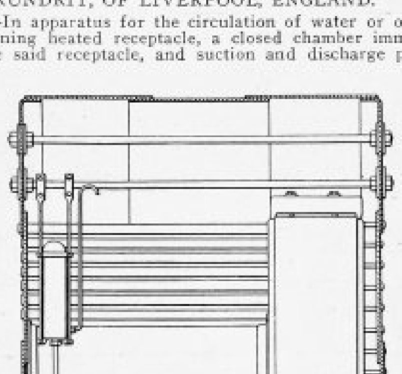
908,669. FLUE-EXPANDER. JAMES PAYTON HIGH, OF FAIRVIEW, OKLA.

Claim 1.—A flue expander comprising a bar of uniform cross sectional diameter throughout its entire length, a hollow expanding member loosely mounted for sliding movement thereon and having an uninterrupted frustoconical exterior surface, and a similar interior surface, the

interior of the expanding member being of greater diameter than that portion of the bar whereon the member is mounted, a stop carried by one end of the bar, and an impact collar secured to said bar in spaced relation to the opposite end thereof and provided with a square shoulder adapted to engage the adjacent end of the expanding member. Two claims.

908,738. PUMP, CIRCULATOR, AND LIKE APPLIANCE. JOSEPH BRUNDRIT, OF LIVERPOOL, ENGLAND.

Claim 1.—In apparatus for the circulation of water or other liquid, a liquid containing heated receptacle, a closed chamber immersed in the liquid in the said receptacle, and suction and discharge pipes, both of



which are connected at one end with the lower part of the said chamber, while the other end of the suction pipe is open to the liquid near to the bottom of the receptacle and the other end of the discharge pipe to the upper portion of the receptacle. Four claims.

908,879. BOILER FURNACE. PATRICK HENRY McGIEHAN, OF GARNERVILLE, N. Y.

Claim 1.—A boiler furnace, comprising a brick-work for supporting the boiler, a fire box in the said brick-work underneath the front end of the boiler, a bridge wall, a perforated transverse wall a distance in the rear of the bridge wall, to form with the latter a main combustion chamber, and to form with the rear end of the brick-work a second combustion chamber leading to the boiler flues, and an air pipe extending through the said second combustion chamber and through the said perforated wall into the main combustion chamber to supply the latter with heated air, said pipe having its discharge opening directed downward, and below the level of the fire-box. Two claims.

908,913. FURNACE. ROBERT L. WALKER, OF BROOKLYN, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO MALCOLM GREEN, OF BOSTON, MASS., AND JAMES N. CATLOW, OF NEW YORK, N. Y., TRUSTEES.

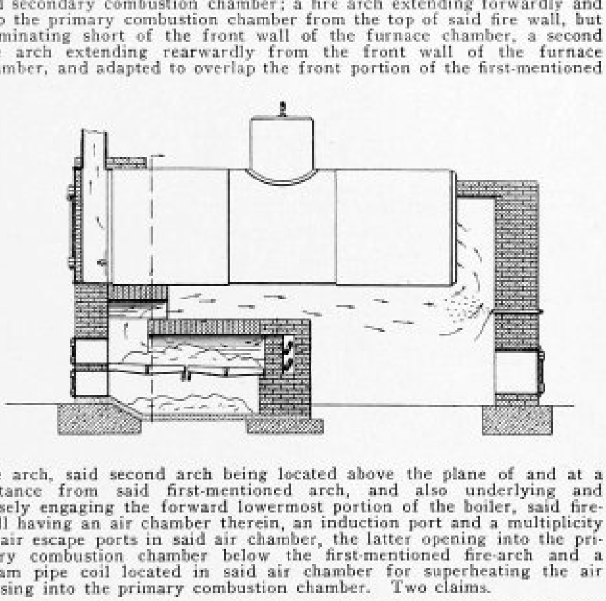
Claim 2.—In boiler furnaces, a fire-box having masonry side walls, a boiler, water legs extending downward therefrom adjacent the outer surface of the side walls of said fire-box to allow the water circulating in said water legs to cool, a grate, a hollow deflector mounted above said grate, means extending from said deflector into the water leg to allow the comparatively cold water within the water leg to flow into the deflector, and a connection between said deflector and said boiler. Two claims.

909,013. BOILER-FEEDING APPARATUS. NATHAN E. NASA', OF TORONTO, CANADA.

Claim.—In a boiler-feeding apparatus, a vessel having a steam and a water supply whereby water is maintained therein at a height corresponding to that of the water in a boiler connected therewith, combined with a shell which is screwed into the wall of the vessel and whose interior is in communication with the interior of the vessel, the wall of the said shell having therein an inlet passage for air under pressure and an outlet air channel leading from the said passage; a shaft with a pointed end which passes through one side of the shell and whose point rests in a conical depression in the opposite side of the shell, the said shaft having a spherical collar; a bored plug having a hemispherical depression on its inner end, which is placed over the projecting portion of the shaft to hold the same steam tight in place; an arm fastened to the said shaft; a double-faced valve hinged to the said arm, to admit of the passage of air through the device, or prevent such passage and admit of the escape of air which has passed through the device; a lever fastened to the shaft at a point within the shell, and which extends to the interior of the vessel; and a float situated in the vessel and suspended from the said lever. One claim.

909,218. FURNACE. GEORGE PRESCOTT, OF MINNEAPOLIS, MINN.

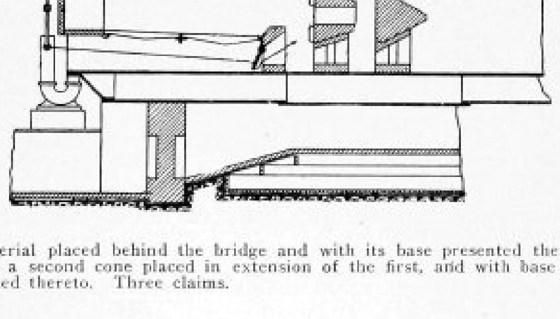
Claim 1.—In a furnace, the combination of a furnace chamber, and a boiler located therein, a fire wall dividing said chamber into a primary and secondary combustion chamber; a fire arch extending forwardly and into the primary combustion chamber from the top of said fire wall, but terminating short of the front wall of the furnace chamber, a second fire arch extending rearwardly from the front wall of the furnace chamber, and adapted to overlap the front portion of the first-mentioned



fire arch, said second arch being located above the plane of and at a distance from said first-mentioned arch, and also underlying and closely engaging the forward lowermost portion of the boiler, said fire-wall having an air chamber therein, an induction port and a multiplicity of air escape ports in said air chamber, the latter opening into the primary combustion chamber below the first-mentioned fire-arch and a steam pipe coil located in said air chamber for superheating the air passing into the primary combustion chamber. Two claims.

909,488. FURNACE. ANTON WARDZINSKI, OF BROMBERG, GERMANY.

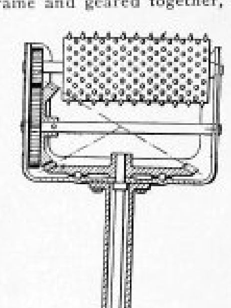
Claim 1.—The combination in a furnace of a fire-bridge having an opening communicating with the ashpit, a perforated cone of refractory



material placed behind the bridge and with its base presented thereto, and a second cone placed in extension of the first, and with base presented thereto. Three claims.

909,235. BOILER-SCALE-REMOVING APPARATUS. ADOLPH SCHRÖR, OF BREMEN, GERMANY.

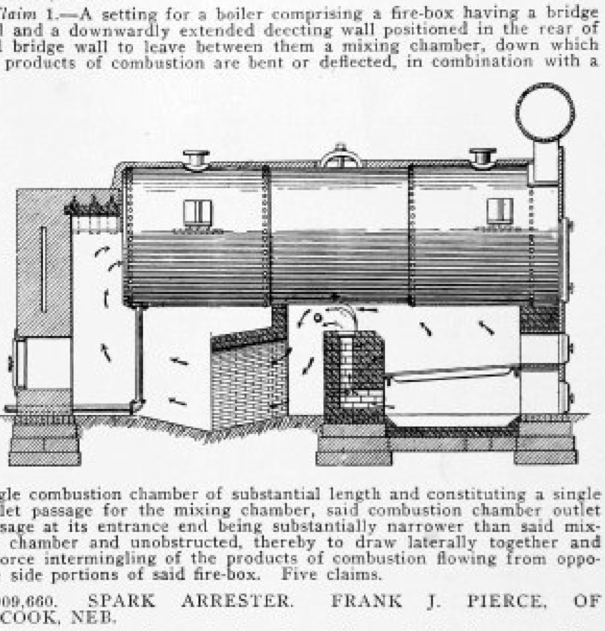
Claim 1.—The herein-described apparatus for removing boiler scale, comprising a frame including a forked head and a tubular handle attached to said head, two parallel shafts journaled in the side members of the head of the frame and geared together, a cleaning roll mounted



on one of said shafts, a bevel gear connected to the other shaft, a driving shaft extending through the tubular handle and into the head piece of the frame, and a second bevel gear secured to the end of said shaft within the head piece of the frame and meshing with the aforesaid bevel gear. Two claims.

909,805. BOILER-SETTING. DWIGHT F. KILGOUR, OF LEXINGTON, MASS.

Claim 1.—A setting for a boiler comprising a fire-box having a bridge wall and a downwardly extended deecting wall positioned in the rear of said bridge wall to leave between them a mixing chamber, down which the products of combustion are bent or deflected, in combination with a



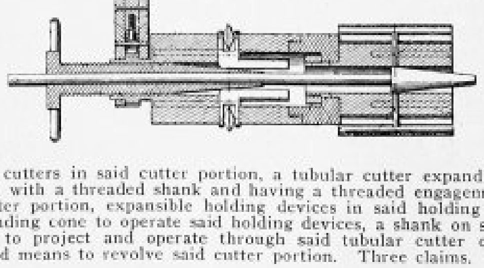
single combustion chamber of substantial length and constituting a single outlet passage for the mixing chamber, said combustion chamber outlet passage at its entrance end being substantially narrower than said mixing chamber and unobstructed, thereby to draw laterally together and enforce intermingling of the products of combustion flowing from opposite side portions of said fire-box. Five claims.

909,660. SPARK ARRESTER. FRANK J. PIERCE, OF McCOOK, NEB.

Claim 4.—A spark arrester for locomotives and the like, comprising a horizontally disposed frame adapted to be arranged in the smoke box above the lower end of the baffle plate, the said frame having a depending box portion through the bottom of which extends the exhaust nozzle, perforate panels having trunnions at the middle of their ends and journaled in the said frame and its depending box portion, and means under the control of the engineer for rocking the said panels, whereby adjacent panels will be swung in opposite directions to cause their side edges to contact to form a zigzag surface. Eleven claims.

910,547. ROLLER TUBE-CUTTER. ARTHUR P. KOHLER, OF JUNCTION CITY, KAN.

Claim 1.—In a tube cutter, a sectional holding portion, means to detachably secure the sections of said portion together, a sectional cutter portion revolubly mounted on said holding portion, means to detachably connect the sections of said cutter portion together, a series of ex-



pansible cutters in said cutter portion, a tubular cutter expanding cone provided with a threaded shank and having a threaded engagement with said cutter portion, expansible holding devices in said holding portion, an expanding cone to operate said holding devices, a shank on said cone adapted to project and operate through said tubular cutter operating cone, and means to revolve said cutter portion. Three claims.

THE BOILER MAKER

APRIL, 1909

INCRUSTATION AND CORROSION.

Causes and Prevention in Steam Boilers and Pressure Vessels of the Varied Industries.

BY R. E. M'NAMARA.

PACKING HOUSE VESSELS.

The pressure vessels of an animal packing house consist chiefly of rendering tanks, jacketed kettles and dryers, there being several types of each often used at the same plant. The rendering tank, Fig. 2, is the most important of them all. In a large establishment where there are twenty or more in one battery, they are known locally as beef tanks, hog tanks, lard tanks, fertilizer tanks, etc., thus designating the purpose for which used. In the rendering of animal products through these tanks corrosive elements are spontaneously generated. They are known as the fatty acids and consist of oleic, stearic and palmitic acids. These are the acids which also pit the interior of high-pressure engine cylinders and they occasionally find their way from the cylinder through the open heater into the boiler. In composition there is much similarity; thus, for oleic we have $C_{17}\ H_{33}\ CO_2\ H$, for stearic $C_{17}\ H_{35}\ CO_2\ H$, for palmitic $C_{15}\ H_{31}\ CO_2\ H$. The specific gravity of palmitic acid is one, they are all colorless, odorless and insoluble in water, but readily dissolve in alcohol. Nitric and sulphuric acid also decompose or dissolve them.

Considering the nature of the products cooked in these tanks, it is not possible to counteract the corrosive elements with these acids; hence, rendering tanks have to be carefully watched and at ninety-day intervals are examined by hammer test and expert ocular inspection. As the plates are generally quite uniformly corroded (except at the bottom) it is often a difficult problem to determine the real thickness of a plate without drilling, or the margin of safety under which the tank is working. Rendering tanks are built of 3/8 to 9/16-inch steel plate, from 60 to 72 inches in diameter and from 12 to 16 feet in length and generally cook under a pressure of 40 pounds. Thus, when new, they have a great margin of safety. After a few years' time, however, if regularly used, the upper and lower rings become unformly wasted, sometimes being only 1/8 inch thick and yet presenting as smooth and perfect an appearance as the original 1/2-inch plate. The top ring on the outside at the floor line often wastes from 30 to 40 percent from external corrosion. In up-to-date construction the floor is therefore cut away for several inches around the tank and a plastering of cement is built from the top head outwards to prevent the corrosive action of the tricklings. The bottom head and last course in "beef tanks" suffer grievously from pitting which, unlike the uniform wasting or corrosion in "hog tanks," is purely local and will often attack the plate only in patches of small area. The laps and rivets are also at times subjected to violent action, the rivet heads being eaten off to such an extent that they (the rivets) may be easily driven out of their own holes. The head seams when the flange is set into the shell forms a minute shelf where, owing to the specific gravity of the acid and the stagnant circulation at this point, it often grooves considerably. To assist circulation and prevent acid reaction on the bottom head and courses, false bottoms of perforated cast iron are introduced and set up from the bottom head

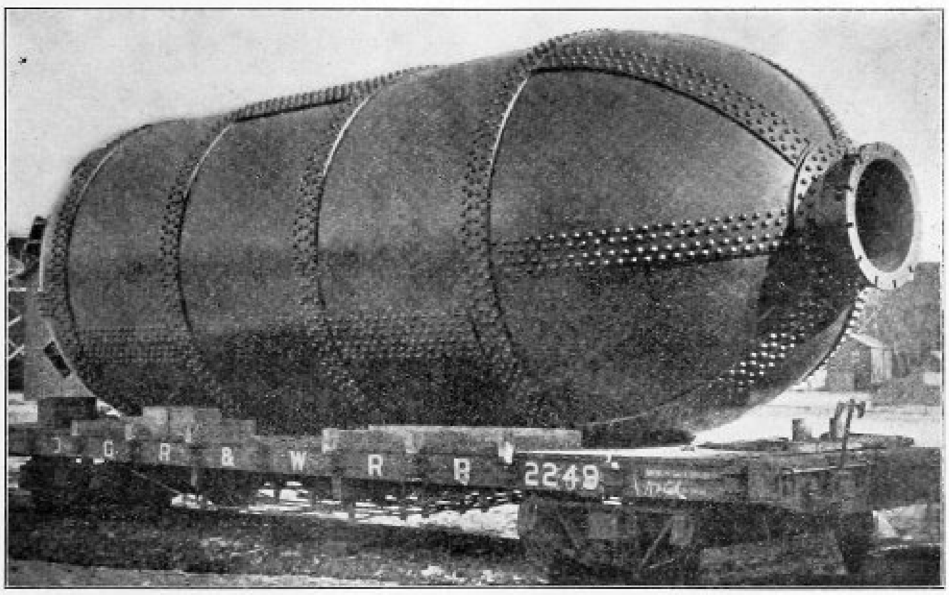


FIG. 1.—DIGESTER FOR MAKING PULP BY THE SULPHITE PROCESS.

from 4 to 8 inches; the flange of the head is also placed outside of the shell, as shown in Fig. 2, and all laps turned downward. When the longitudinal seams are lap jointed, an inner strap is riveted over them, making what is known as a "Dutch

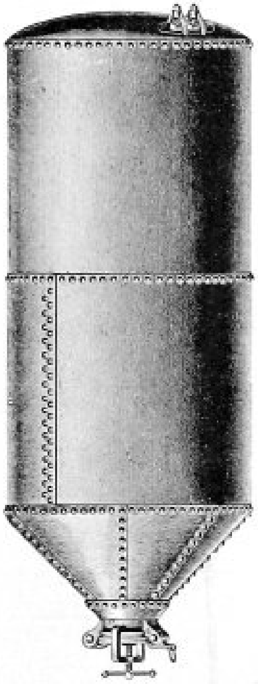


FIG. 2.—A RENDERING TANK.

joint." This also tends to increase the joint efficiency. While the above measures are all beneficial and tend to prolong the life of the vessel several years, all tanks will in time depreciate to the same point, whether safeguarded by precautionary measures or not; hence, rigid inspection and care are essential to their safe operation.

through which the stock passes, being stirred and guided on its way by radial vanes attached to a long shaft, one being placed centrally in each tube and revolved by belting, roughly speaking. Therefore, an Anderson dryer resembles a 3-furnace marine Clyde baffle-back boiler without smoke flues, the stock having to pass through each of the three tubes. Entering at the top as a pasty, mushy mass, it is heated to 250 degrees Fahrenheit and leaves at the bottom loose and dry. The smell of one of these cooking dryers can better be imagined than described. For this reason they are generally kept in a separate building known as the fertilizer house. The dry product being rich in ammonia and nitrogenous compounds, is sacked and sold for land fertilizing purposes. Most of the product having previously passed through the rendering tanks is deprived of the greater percent of the fatty acids; the ammonia present being an alkali would neutralize the corrosive action in a slight degree if either were in excess. The inner tubes externally, however, do not suffer from corrosion or pitting only in exceptionally favorable cases.

The chief depreciation is due to the attrition of the moving mass and often to the scraping of the agitator blades, as there is considerable sag in a shaft 30 feet long and the ends of the blades are only supposed to clear 3/8 inch all the way around. The inner tubes are built of 7/16 by 1/2 inch steel rolled to form a butt joint with one cover plate, the rivets being driven countersunk. The tube thus, although built in several sections, has a smooth bore and unless grooved or cut by the agitator paddles will wear quite uniformly. Hammer testing alone will reveal thinness in these tubes. When worn to 3/16 inch they are replaced by new ones.

The interior of the shell of an Anderson dryer, whether fired externally or heated by steam, has to be carefully watched for corrosion, especially if cooking under low pressure, because the same water and returns are used over and over; again, their interiors are difficult of access and much of the surface between the tubes can not be seen at all. For these reasons dryers may be classed among the more dangerous vessels and are in well-regulated plants carefully gone

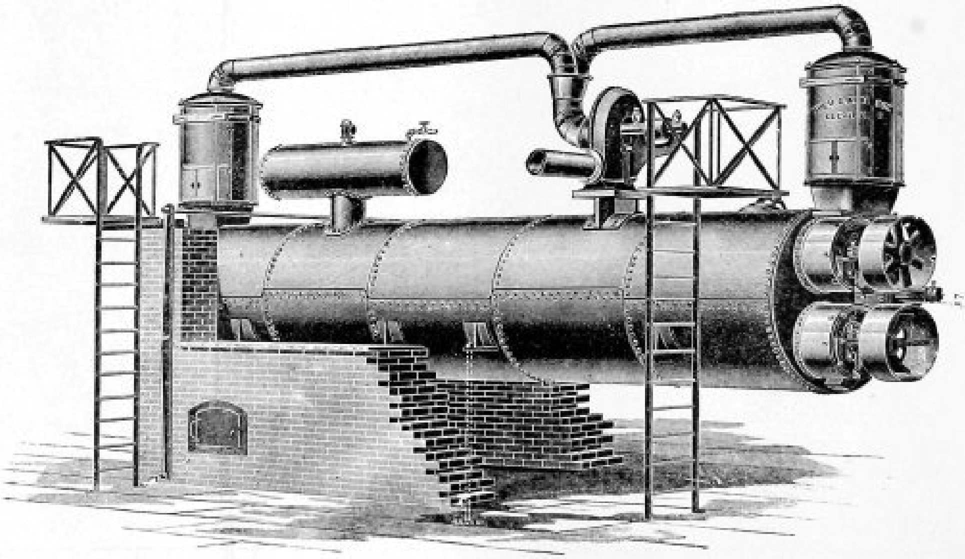


FIG. 3.—AN ANDERSON DRYER FOR COOKING AND DRYING CONCENTRATED TANKAGE IN A PACKING HOUSE.

The Anderson dryer, Fig. 3, is a cylindrical vessel from 6 to 8 feet in diameter and 25 feet in length, built of boiler steel and may be either externally fired or heated by live steam through a reducing valve at a pressure of 80 pounds. It is used for cooking and drying the concentrated tankage, consisting of all kinds of refuse, filth and waste. The shell proper contains three internal tubes 26 inches in diameter,

over every ninety days. The shafts, of course, have to be pulled out to facilitate examination of the tubes, making it a troublesome and disagreeable task for all concerned. For this reason they are gradually going out of use, hot-air drying systems replacing them. The inner tubes being subjected to collapsing pressure, are often reinforced around their outer circumference by wrought angle or tee-iron bands as a precautionary measure. Thus, in case of undue thinness, due to wear in any one spot, the rupture will only be local. Internal pitting, when confined to the shell alone, may be stopped by the use of cement, which possesses the advantage that inasmuch as no scale is deposited the cemented spots are always distinguishable and increased action may be readily noted. Other recommendations applicable will be found under the heading "Pitting in low-pressure systems."

Smith shell dryers, Joslyn stick dryers, Gubbins and Cook dryers differ considerably both in appearance and usefulness. With the exception of the Joslyn stick-drying rolls, Fig. 4, they all have an inner shell of boiler steel and are staybolted to an outer envelope or wrapper sheet, Fig. 5, being a drawing of the Smith shell dryer used for drying crushed bone, horns and animal hoofs, the product afterward being converted into fertilizer, bone meal, glue and Prussian blue. The inner shell is subjected to collapsing pressure and wear from the moving product, same being stirred by a revolving agitator and being cooked with high-pressure steam, they suffer but little from internal corrosion. The wearing portion of the inner shell, however, has to be periodically renewed, or occasionally, when worn on the bottom half alone, the dryer is turned half over and run as before. The staybolt heads also often wear 1/16 inch to 3/32 inch below the surface of the sheet. Grooving is also a frequent occurrence.

The Joslyn stick-drying roll, Fig. 4, is a cast-iron hollow cylindrical vessel 48 inches in diameter and 10 feet long, supported at each end by journals which are continuations of each head. They are heated by live steam through the journals and revolve slowly in a bath of concentrated tankage and blood. The lower part only being immersed, the hot surface of the metal as it comes into contact with the liquid causes a portion of it to adhere or stick to the roll, hence the name stick dryer; as the coated part of the roll revolves out of the bath it dries and hardens and is finally removed through the action of a long knife whose cutting edge is held for the full length against the roll by the tension of springs or thumb screws. The shell of these dryers is ordinarily 1⅛ inches thick for a working pressure of 40 pounds. The constant chafing of the knife blade, however, sometimes reduces the margin of safety to a low point. Stick rolls are sometimes found reduced to ¾ inch in thickness, at which point they have burst with much damage to property. Cast iron being a treacherous metal and also unreliable as far as giving forth a definite sound for a given thickness, stick dryers are gradually being replaced by vacuum evaporators. The stick dryer in general depreciates only from wear on its external surface, due, as stated, to friction of the knife blade. In rare cases, however, when on a low-pressure steam line, they have been known to groove, as the exterior surface must be smooth and straight, so as not to interfere with the action of the stripping knife. When for any cause it is necessary to patch them, the roll has to be dismantled, the bolted head removed and the patch applied internally, care being taken not to drill the patch bolt holes quite through the shell. Rivets cannot be used.

As there are about 1,600 paper mills in this country alone, the manufacture of Bertram boilers or globe rotaries, bleachers and digesters for their use forms an important part of the boiler-making industry. Although the manufacture

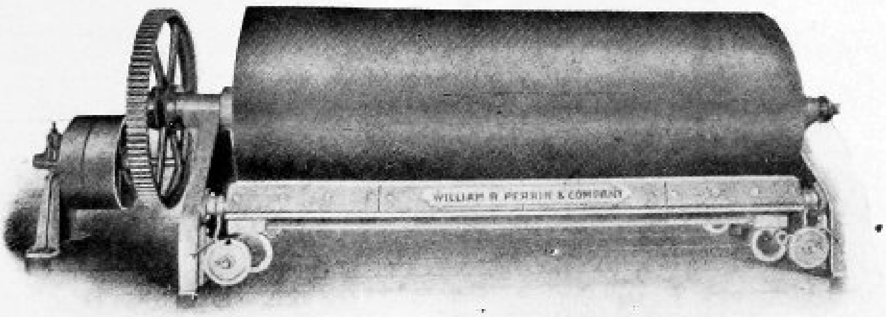


FIG. 4.—A JOSLYN STICK DRYER.

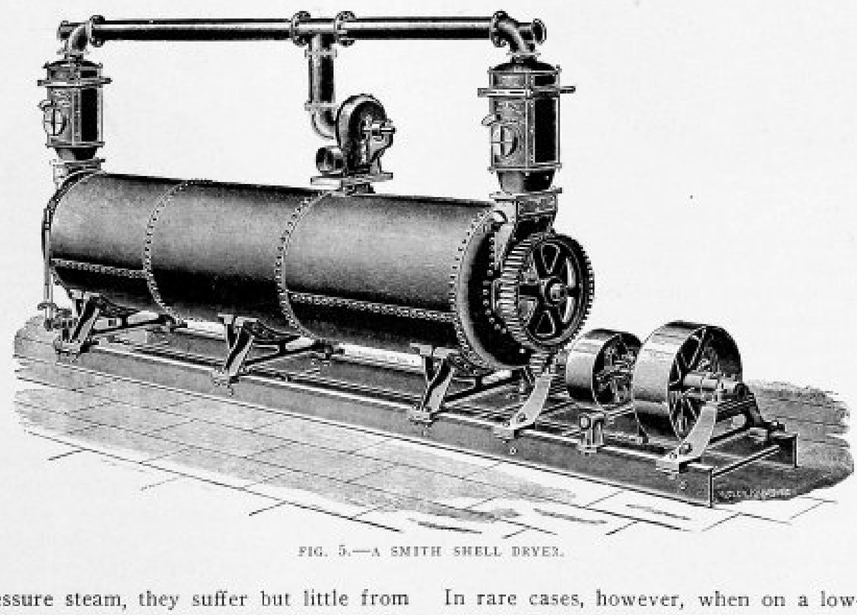


FIG. 5.—A SMITH SHELL DRYER.

of same would be an interesting subject, as they are not so well known, it will be the purpose of the writer only to discuss their use, the deteriorating influences to which they are subjected and the chemical reagents in use as a counteractant.

The chief materials from which paper and pulp are made are, for wood pulp, hemlock, aspen and spruce; for straw pulp, wheat, oat, rye and barley straw. In a wood-pulp mill, the vessel of reduction is known as a digester. Fig. 1 is a fair sample of those generally found in use. It is 14 feet in diameter and 40 feet in length, built of 7/8 inch steel, and when in place ready for use, assumes a vertical position. Globe rotaries or Bertam boilers, as used in the straw-pulp mills, are spherical in shape and built from 12 to 14 feet in diameter, of 3/4-inch plate, triple lap jointed; they are of both steel and copper. See Figs. 6 and 7.

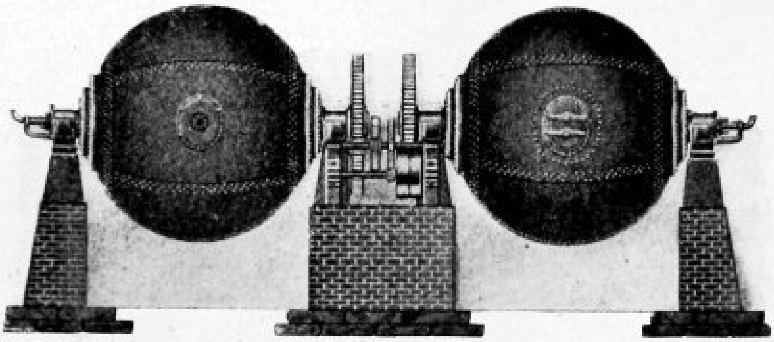


FIG. 6.—GLOBE ROTARIES FOR THE MANUFACTURE OF PULP BY THE SODA PROCESS.

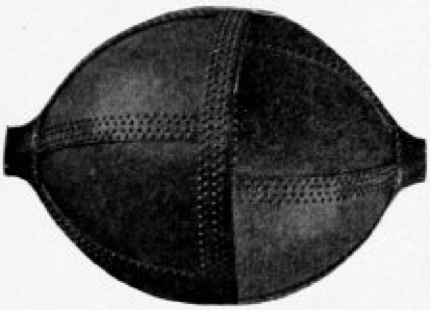


FIG. 7.

In the manufacture of pulp or "straw-board," the chief processes in vogue are known as the "soda process" and the "sulphite process." Both are entirely chemical, and depend for their success upon the extraction of the cellulose ($C_6 H_{10} O_5$) from the gummy and resinous matter in the raw material.

FIG. 8.—REDUCING VALVE.

THE SODA PROCESS.

In the soda process the globe rotaries, Figs. 6 and 7, are filled with straw and 10 pounds of 75 percent caustic soda are added to each 100 pounds of material, whether oat, wheat straw or esparto grass. Live steam is admitted through one of the cast-iron trunnions, which also acts as a journal. The rotary is then started to revolving slowly by machinery and the contents cooked for from 3 to 4 hours at a pressure of from 25 to 45 pounds. As the boilers which furnish steam for power also have other work to perform, which may require a pressure of 100 pounds or more, these rotaries cannot be connected directly to them. The steam pressure is therefore equalized by means of a reducing valve, as shown in Fig. 8, which can be weighted to receive steam at 125 pounds on one side and deliver it at 20 pounds on the other. This steam line is also provided with one or more check valves, a non-return valve and an emergency safety valve set at a few pounds above the desired working pressure on the rotary. The check and non-return valves prevent the saturated liquor from backing up into the boilers.

The soda process being alkaline, the steel in these vessels suffers but little from depreciation. There are times, however, when there is a scarcity of straw and the next available material is taken from packing houses and is known as paunch manure, being the undigested remnants found in the stomachs of cattle. As it contains but little ammonia or nitrogenous compounds it is of small value, too bulky to be used as a fertilizer, and unless bought by the paper mills is mixed with coal and burned as boiler fuel. This paunch manure when cooked in a rotary, although the acids are, in a measure, neutralized by the alkaline resolvents, exhibits corrosive propensities, which readily attack the steel plates and often honey-comb the sheet without it being noticed, as it eats under the protective lining formed by the action of the soda with the resinous matter separated from the product. Copper vessels themselves are not entirely immune from this deterioration. The honey-combing thus brought about, when discovered in time, may be stopped by cleaning the interior of the rotary, whether of steel or copper coating, with some non-corrosive adhesive mixture, such as red lead and oil or "Smooth-On."

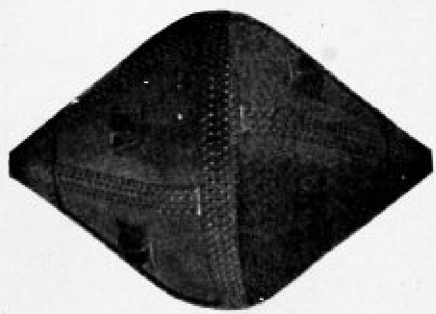


FIG. 9.—VULCANIZER.

THE SULPHITE PROCESS.

In the sulphite process, the vertical digester, Fig. 1, is loaded with wood chips and cooked with bisulphate of lime and magnesia and sulphurous acid at from 90 to 100 pounds pressure for varying intervals of time. The liquor used in this process being a concentrated acid, cannot be neutralized by any methods save those which would thwart the purpose for which it was intended. If the acid was allowed to react upon the plate, however, an expensive digester would be corroded through and destroyed in an incredibly short space of time. Therefore, the only method available as a counteractant is to line the inner surface of the shell with some refractory material. Experiments have shown that pure sheet lead is one of the most satisfactory materials for resisting these acids, for when the acid and the lead are in contact, lead sulphite is formed, which is insoluble. A small portion of antimony in the lead is also beneficial. Lead, although being an ideal lining in this respect, has several drawbacks, which prevent its use as a universal antidote, chief of which is its unequal expansion powers when compared with steel. Having a lead lining alone, the varying temperature would in time cause the inner shell to contract and leave an unprotected annular space between it and the outer shell. The acidular action in this space, due to leakage, would likely lead to disastrous results, as it would ordinarily remain unobserved, for no inspection could reveal it unless a portion of the leaden sheet was cut out for examination. If this were done, then a joint could not again be readily made. In practice, therefore, lead, when used, is always reinforced by some other material, cement and brick being the most common. They are set as follows: One-half inch sheet of lead, 1 to 2 inches of cement, one course of brick. Other materials used are glass, sulphate of lime and double silicates of iron and lime, glazed and vitrified tiling, etc.

Digester liquor, like coal oil and molasses, is very penetrative and extremely hard to hold in any vessel; the seams and rivets at times become coated, due to seepage and leakage. These distress signs are indicative of a cracked or defective lining, which, though an expensive matter, must frequently be renewed.

There are other acid paper processes patented, of which the "nitric hydrochloric" is one. Parts of the operation are dangerous, as nitric acid and cellulose belong to the gun-cotton series and are explosive. One of the several reasons, however, why it is not in more general use is on account of the difficulties encountered in procuring a pressure vessel in the shape of a digester which can safely stand the high pressure and powerful corrosives incidental to its manufacture.

In many other departments of the varied industries, such, for instance, as sugar refineries, rubber regenerating works, oil refineries and the manufacture of corn products, the pressure vessels vary in form, size and material and are known locally under a variety of names, vulcanizers, converters, clarifiers, bleachers and stills being the most common. They can all be grouped, however, under the head of converters, as primarily they are used for the conversion of one substance or compound into another through the influence of heat and chemicals. Thus, in corn product refineries, starch is converted into glucose through the action of muriatic acid while under pressure in a copper vessel similar to the digester, Fig. 1. To those of us who have seen locomotive injectors cleaned of lime in a muriatic acid bath, where the injector is withdrawn and cleaned as soon as the lime bubbles cease in order to prevent acid reaction on itself, it would appear to be a case of courting certain disaster to use a copper vessel for this reaction in the starch and muriatic process. Steel and iron shells, however, have been tried and found wanting. True, the copper is also wasted considerably by internal and uniform corrosion, especially from the lap to the liquor line. As the bottom two-thirds of the shell, however, does not depreciate to a noticeable degree, it is customary to build the top course out of ⅞-inch material, second course ¾ inch and the balance ⅝ inch. The two top rings are periodically renewed and when the segment head is affected enough to warrant, the vessels are inverted and continued in service, repairing as before. Since rolled-sheet copper only has a tensile strength of about 24,000 pounds, these vessels are limited in size as to diameter, it being considered safer to run several small ones rather than one large one, although less economical. These remarks, however, do not apply to copper globe rotaries or Bertam boilers, for, as they are spherical, they can sustain twice the pressure of a cylindrical shell of equal diameter, material and thickness being the same.

Converters not specifically mentioned or classified under the general head in this article were omitted purposely, for in general it may be stated that where subject to deteriorating influences, the remedial measures applicable to rotaries and digesters will also apply to converters irrespective of location or use.

In conclusion we might state, steam boilers and pressure vessels, unlike plants and animals, have no recuperative powers of their own; therefore, in their care and operation an extraordinary amount of attention, skill, diligence and observation is essential to their economical operation and safety. The wonder is not why so many explode, but why so few. Since but a small percentage of those which are subjected to periodical inspection ever give trouble it speaks well for the inspection department of insurance companies who carry the risks. Unfortunately, however, it is only the most progressive firms who appreciate the value of the insurance features. Experience and time are the factors which it will take to convince the remainder.

SAFETY VALVE CAPACITY.*

BY PHILIP G. DARLING.

The function of a safety valve is to prevent the pressure in the boiler to which it is applied from rising above a definite point, to do this automatically and under the most severe conditions which can arise in service. For this, the valve or valves must have a relieving capacity at least equal to the boiler evaporation under these conditions. If they have not this capacity, the boiler pressure will continue to rise, although the valve is blowing, with a strain to the boiler and danger of explosion consequent to over-pressure. Thus with the exception of a requisite mechanical reliability, the factor in a safety valve bearing the most vital relation to its real safety is its capacity.

It is the purpose of this paper to show an apparatus and method employed to determine safety-valve lifts, giving the results of tests made with this apparatus upon different valves; to analyze a few of the existing rules or statutes governing valve size and to propose a rule giving the results of a series of direct capacity tests upon which it is based; its application to special requirements, and finally to indicate its general bearing upon valve specifications.

Two factors in a safety valve geometrically determine the area of discharge and hence the relieving capacity; the diameter of the inlet opening at the seat and the valve lift. The former is the nominal valve size, the latter is the amount the valve disc lifts vertically from the seat when in action. In calculating the size valves to be placed on boilers, rules, which do not include a term for this valve lift, or an equivalent, such as a term for the *effective* area of discharge, assume, in their derivation, a lift for each size valve. Nearly all existing rules and formulas are of this kind, which rate all valves of a given nominal size as of the same capacity.

To find what lifts standard make valves actually have in practice and thus test the truth or error of this assumption that they are approximately the same for the same size valve,

* Read before the American Society of Mechanical Engineers, February, 1909.

an apparatus has been devised and tests upon different makes of valves conducted. With this apparatus not only can the valve lift be read at any moment to thousandths of an inch, but an exact permanent record of the lift during the blowing of the valve is obtained somewhat similar to a steam engine indicator card in appearance and of a quite similar use and value in analyzing the action of the valve.

As appears in the accompanying engraving, the valve under test is mounted upon the boiler in the regular manner, and a small rod is tapped into the top end of its spindle, which rod connects the lifting parts of the valve directly with a circular micrometer gage, the reading hand of which indicates the lift upon a large circular scale or dial. The rod

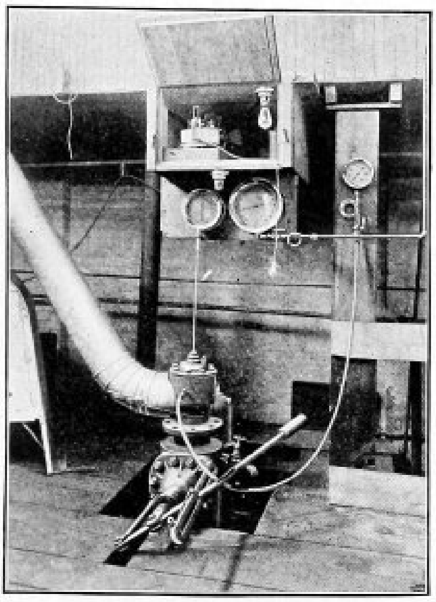


FIG. 1.—APPARATUS USED IN LABORATORY TESTS.

through this gage case is solid, maintaining a direct connection to the pencil movement of the recording gage above. This gage is a modified Edison recording gage with a multiplication in the pencil movement of about 8 to 1, and with the chart drum driven by an electric motor of different speeds, giving a horizontal time element to the record. The steam pressures are noted and read from a large test gage graduated in pounds per square inch, and an electric spark device makes it possible to spot the chart at any moment, which is done as the different pound pressures during the blowing of the valve are reached. The actual lift equivalents of the pencil heights upon the chart are carefully calibrated so the record may be accurately measured to thousandths of an inch.

In testing, the motor driving the paper drum is started and the pressure in the boiler raised. The valve being mounted directly upon the boiler, then pops, blows down and closes under the exact conditions of service, the pencil recording on the chart the history of its action.

With this apparatus, investigations and tests were started upon seven different makes of 4-inch stationary safety valves, and these tests were followed with similar ones upon nine makes of muffler locomotive valves, six of which were 3½ inches, all the valves being designed for and tested at 200 pounds. The stationary valve tests were made upon a 94-horsepower watertube boiler made by the Babcock & Wilcox Company. The locomotive valve tests were made upon locomotive No. 900 of the Illinois Central Railroad, the valve being mounted directly upon the top of the main steam dome. This locomotive is a consolidation, having 50 square feet of grate area and 2,953 square feet of heating surface. Although a great amount of additional experimenting has been done, only the results of the above will be quoted in this paper. These lift records show (with the exception of a small preliminary simmer, which some of the valves have) an abrupt opening to full lift and an almost equally abrupt closing when a certain lower lift is reached. Both the opening and closing lifts are significant of the action of the valves.

The results of the 4-inch iron body stationary valve tests summarized are as follows: Of the seven valves the average lift at opening was .079 inch, and at closing .044 inch, or excluding the valve with the highest lifts, the averages were .07 inch at opening and .037 inch at closing. The valve with the lowest lifts had .031 inch at opening, and .017 inch at closing, while that with the highest had .137 inch and .088 inch. Expressing the opening lifts as percents of the highest, the lowest had 31.4 percent, the next larger 40.8 percent, and the next 46.6 percent. Of the six 3½-inch muffler locomotive valves, the summarized lifts are as follows: Average of the six valves, .074 inch at opening and .043 inch at closing. Average excluding the highest, .061 inch at opening and .031 inch at closing. The lowest lift valve had .04 inch opening and .023 inch closing; the highest .140 inch opening and .102 inch closing. As percents of the highest, the lowest lift valve was 36.4 percent, the next larger 39.8 percent, and the next 46.4 percent.

The great variation—300 percent—in the lifts of these standard valves of the same size is startling and its real significance is apparent when it is realized that under existing official safety valve rules these valves, some of them with less than one-third the lift and capacity of others, receive the same rating and are listed as of equal relieving value. Three of these existing rules are given as an illustration of their nature; the United States Supervising Inspectors' Rule, the Boiler Inspection Rule of Philadelphia, and the rule of the Board of Boiler Rules of Massachusetts.

RULE OF THE UNITED STATES BOARD OF SUPERVISING INSPECTORS.

$$A = .2074 \times \frac{W}{P}$$

A = area of safety valves in square inches per square foot of grate surface.

W = pounds of water evaporated per square foot of grate per hour.

P = boiler pressure (absolute).

In 1875 a special committee was appointed by this board to conduct experiments upon safety valves at the Washington

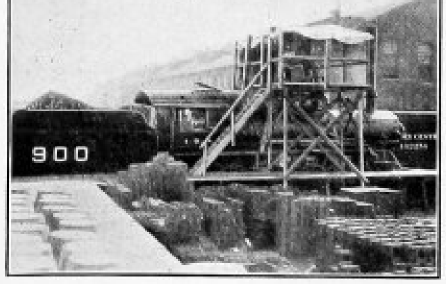


FIG. 2.—VIEW OF LOCOMOTIVE TESTING PLANT.

navy yard. Although the pressures used in these experiments (30 to 70 pounds per square inch) were too low to make the results of much value to-day, one of the conclusions reported is significant.

"First.—That the diameter of a safety valve is not an infallible test of its efficiency.

"Second.—That the lift which can be obtained in a safety valve, other conditions being equal, *is* a test of its efficiency."

The present rule of the board as given above, formulated by Mr. L. D. Lovekin, chief engineer of the New York Shipbuilding Company, was adopted in 1904. Its derivation assumes practically a 45-degree seat and a valve lift of 1/32 of the nominal valve diameter. The discharge area in this rule is obtained by multiplying the valve lift $\frac{D}{32}$ by the valve circumference ($\pi \times D$) and taking but 75 percent of the result to allow for the added restriction of a 45 degrees over a flat seat. The 75 percent equals approximately the sine of 45 degrees, or .707. This value for the discharge area, *i. e.*, ($.75 \times \pi \times \frac{D^2}{32}$) is substituted directly into Napier's formula for the flow of steam $W = a \times \frac{P}{70}$. Thus in the valves to which this rule is applied the following lifts are assumed to exist: 1-inch valve, .03 inch; 3-inch valve, .09 inch; 5-inch valve, .16 inch; 2-inch valve, .06 inch; 4-inch valve, .13 inch; 6-inch valve, .19 inch.

Referring back to the valve lifts, it is seen that the highest lift agrees very closely with the lift assumed in the rule, and if the valve lifts of the different designs were more uniformly of this value or if the rule expressly stipulated either that the lift of 1/32 of the valve diameter actually obtained in valves qualifying under it or that an equivalent discharge area be obtained by the use of larger valves, the rule would apply satisfactorily to that size of valve. However, the lowest lift valve actually has but ¼, the next larger less than ⅓, and the average lift of all but the highest lift valve, which average is .07 inch, is but 56 percent of the lift assumed in the rule for these 4-inch valves.

MASSACHUSETTS RULE OF 1909.

$$A = \frac{W \times 70}{P} \times 11$$

A = area of safety valve or valves in square inches per square foot of grate surface.

W = pounds of water evaporated per square foot of grate surface per second.

P = boiler pressure (absolute).

One of the most recently issued rules is that contained in the pamphlet of the new Massachusetts Board of Boiler Rules, dated March 24, 1908. This rule is merely the United States rule given above, with a 3.2 percent larger constant, and hence requiring that amount larger valve. The evaporation term is expressed in pounds per second instead of per hour, and two constants are given instead of one, but when reduced to the form of the United States rule it gives $A = .214 \times \frac{W}{P}$. Figuring this back as was done above with the United States rule and taking the 75 percent of the flat seat area as there done, shows that this rule assumes a valve lift of 1/33 of the valve diameter instead of the 1/32 of the United States rule. This changing of the assumed lift from 1/32 to 1/33 of the valve diameter being the only difference between the two rules, the inadequacy of the United States rule just referred to applies to this more recent Massachusetts rule.

PHILADELPHIA RULE.

$$A = \frac{22.5\,G}{P + 8.62}$$

A = total area of safety valve or valves in square inches.

G = grate area in square feet.

P = boiler pressure (gage).

The Philadelphia rule now in use came from France in 1868, being the official rule there at that time and having been adopted and recommended to the city of Philadelphia by a specially appointed committee of the Franklin Institute, although this committee frankly acknowledged in its report that it "had not found the reasoning upon which the rule had been based." The area (A) of this rule is the effective valve opening, or, as stated in the Philadelphia ordinance of July 13, 1868, "the least sectional area for the discharge of steam." Hence if this rule were to be applied as its derivation by the French requires, the lift of the valve must be known and considered whenever it is used. However, the example of its application given in the ordinance, as well as that given in the original report of the Franklin Institute committee, which recommended it, show the area (A) applied to the nominal valve opening. In the light of its derivation this method of using it takes as the effective discharge area, the valve opening itself, the error of which is very great. Such use, as specifically stated in the report of the committee above referred to, assumes a valve lift at least ¼ of the valve diameter, *i. e.*, the practically impossible lift of 1 inch in a 4-inch valve.

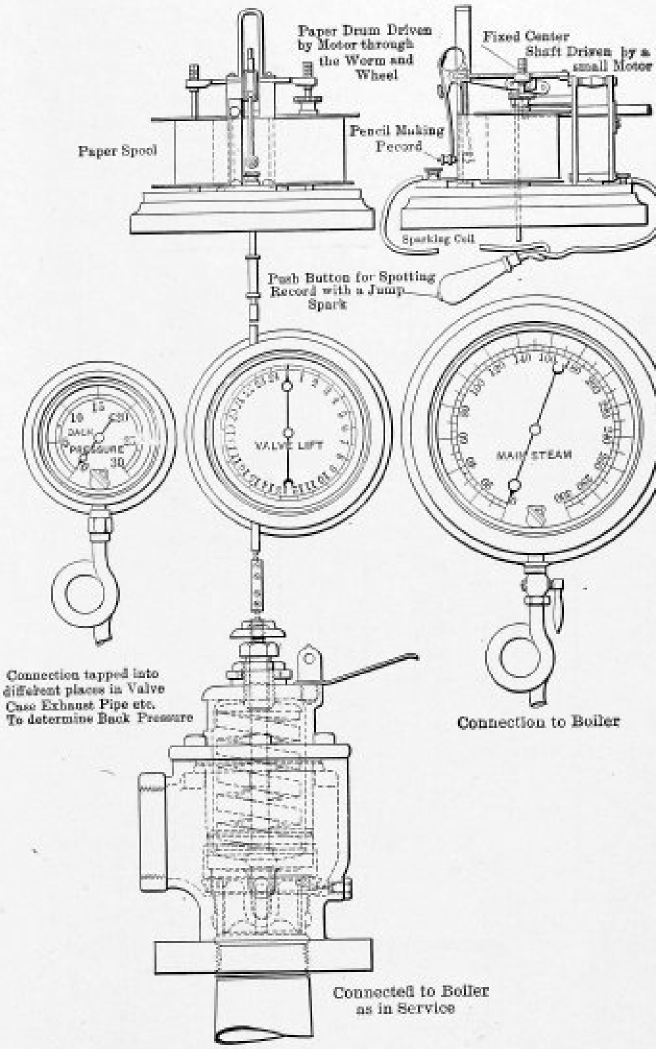


FIG. 3.—APPARATUS USED IN VALVE-LIFT TESTS.

The principal defect of these rules in the light of the preceding tests is that they assume that valves of the same nominal size have the same capacity, and they rate them the same without distinction, in spite of the fact that in actual practice some have but 1/3 of the capacity of others. There are other defects, as have been shown, such as varying the assumed lift as the valve diameter, while in reality with a given design the lifts are more nearly the same in the different sizes, not varying nearly as rapidly as the diameters. And further than this the lifts assumed for the larger valves are nearly double the average actually obtained in practice.

The direct conclusion is this, that existing rules and statutes are not safe to follow. Some of these rules in use were formulated before, and have not been modified since spring safety valves were invented, and at a time when 120 pounds

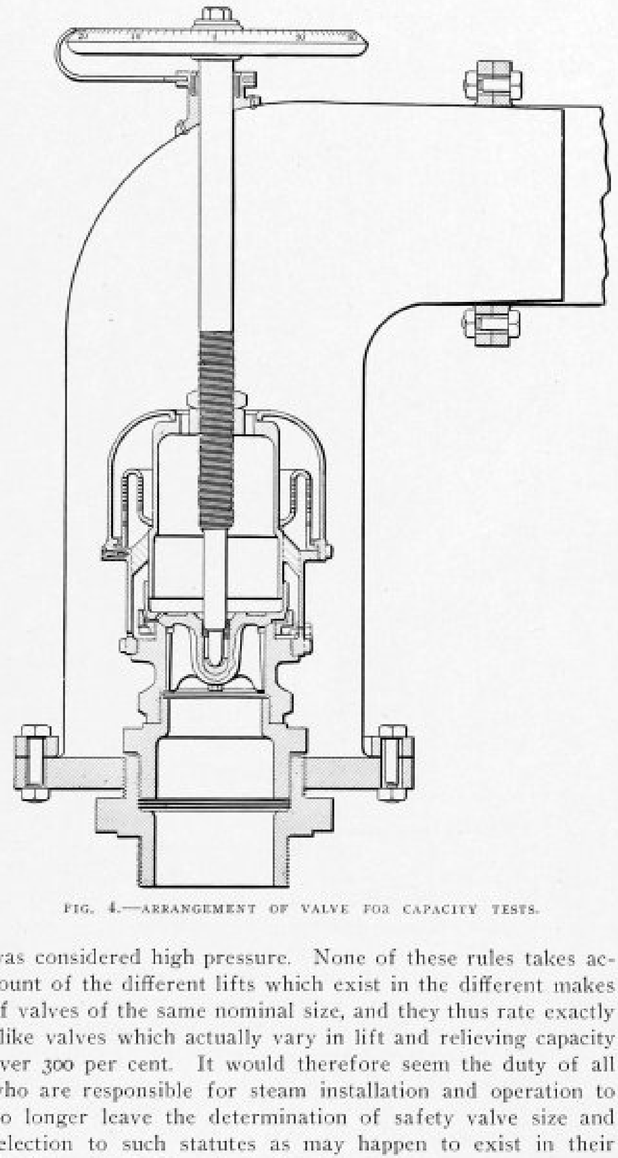


FIG. 4.—ARRANGEMENT OF VALVE FOR CAPACITY TESTS.

was considered high pressure. None of these rules takes account of the different lifts which exist in the different makes of valves of the same nominal size, and they thus rate exactly alike valves which actually vary in lift and relieving capacity over 300 per cent. It would therefore seem the duty of all who are responsible for steam installation and operation to no longer leave the determination of safety valve size and selection to such statutes as may happen to exist in their territory, but to investigate for themselves.

The elements of a better rule for determining safety valve size exist in Napier's formula for the flow of steam, combined with the actual discharge area of the valve as determined by its lift. In "Steam Boilers," by Peabody & Miller, this method of determining the discharge of a safety valve is used. The uncertainty of the coefficient flow, that is, of the constant to be used in Napier's formula when applied to the irregular steam discharge passages of safety valves has probably been largely responsible for the fact that this method of obtaining valve capacities has not been more generally used. To determine what this constant or coefficient of flow is and how it is affected by variations in valve design and adjustment, an extended series of tests has recently been conducted at the Stirling Department of the Babcock & Wilcox Company, at Barberton, Ohio.

A 373-horsepower class K, No. 20 Stirling boiler, fired with a Stirling chain grate, with a total grate area of 101 square feet was used. This boiler contained a U-type of superheater designed for a superheat of 50 degrees F. The water feed to this boiler was measured in calibrated tanks and pumped (steam for the pump being furnished from another boiler) through a pipe line which had been blanked wherever it was possible with stop valves and intermediate open drips to insure that there was no leakage. The entire steam discharge from the boiler was through the valve being tested, all other steam connections from the boiler being either blanked or closed with stop valves beyond which were placed open drip connections to indicate any leakage. A constant watch was kept throughout the testing upon all points of the feed and steam lines to insure that all water measured in the calibrated tanks was passing through the tested valves without intermediate loss.

The valves tested consisted of a 3-inch, 3½-inch and 4-inch iron stationary valve, and a 1½-inch, 3-inch and 3½-inch locomotive valve, the latter with and without mufflers. These six valves were all previously tested and adjusted on steam. Without changing the position of the valve disc and ring the springs of these valves were then removed and solid spindles threaded (with a 10 pitch thread) through the valve casing above inserted. Upon the top end of these spindles, wheels graduated with 100 divisions were placed. The engraving shows the arrangement used with the locomotive valves, the spindle and graduated wheel being similar to that used with the stationary valves. By this means the valve lift to thousandths of an inch was definitely set for each test and the necessity for constant valve lift reading with that source of error eliminated.

In conducting the tests three hours' duration was selected as the minimum time for satisfactory results. Pressure and temperature readings were taken every three minutes, water readings every half hour. A man stationed at the water glass regulated the feed to the boiler to maintain the same level in the boiler during the test, other men were stationed, one at the water tanks, one firing and one taking the pressure and temperature readings. Pressure readings were taken from two test gages connected about 4 inches below the valve inlet, the gages being calibrated both before and after the series of tests was run and corrections applied. In all, twenty-nine tests were run; fifteen were three hours long, four two and a half hours, three two hours and seven of less duration.

Tests numbered 1 to 5 were preliminary runs of but one hour or less duration apiece, and the records of them are thus omitted in the accompanying table, which gives the lifts, discharge areas, average pressure and superheat, and the steam discharge in pounds per hour of each of the other tests. The discharge areas have been figured for 45-degree seats from the formula $A = 2.22 \times D \times L$ plus $1.11 \times L^2$; where A equals the effective area in square inches, D equals the valve diameter in inches, and L equals the valve lift in inches. In tests 8 and 23, where the width of valve seat was .225 inch and .185 inch, respectively, and the valve thus slightly above the depth of the valve seat, the area was figured for this condition.

As previously stated, the application of these results is in fixing a constant for the flow of Napier's formula as applied to safety valves. The formula $W = A \frac{P}{70}$, in which W equals pounds discharged per second, P equals the absolute steam pressure behind the orifice or under the valve, and A equals the effective discharge opening in square inches. This may be stated as $E = C \times A \times P$; in which E equals the pounds steam discharged per hour and C equals a constant, E, A and P being given for the above tests C is directly obtainable.

Figuring and plotting the values of this constant indicate the following conclusions:

(1). Increasing or altering the steam pressure from approximately 50 to 150 pounds per square inch (tests 14 and 10) does not affect the constant, this merely checking the applicability of Napier's formula in that respect.

(2). Radically changing the shape of the valve disc outside of the seat at the huddling or throttling chamber, so-called, does not affect the constant or discharge. In test 15 the valve had a downward projecting lip deflecting the steam flow through nearly 90 degrees, yet the discharge was practically the same as in tests 10 and 14, where the lip was cut entirely away, giving a comparatively unobstructed flow to the discharging steam.

(3). Moving the valve adjusting ring through much more than its complete adjustment range does not affect the constant or discharge. (Tests 16 and 17.)

(4). The addition of the muffler to a locomotive valve does not materially alter the constant or discharge. There is but 2 percent difference between tests 10 and 13.

(5). Disregarding the rather unsatisfactory 1½-inch and 3-inch locomotive valve tests, the different sizes of valves tested show a variation in the constant when plotted to given lifts of about 4 percent.

(6). There is a slight uniform decrease of the constant when increasing the valve lifts.

The variations indicated in the last two conditions are not large enough, however, to materially impair the value of a single constant obtained by averaging the constants of all the 24 tests given. The selection of such a constant is obviously in accord with the other four conditions mentioned. This average constant is 47.5, giving as the formula ($E = 47.5 \times A \times P$). Its theoretical value for the standard orifice of Napier's formula is 51.4, of which the above is 92½ percent.

To make this formula more generally serviceable, it should be expressed in terms of the valve diameter and lift and can be still further simplified in its application by expressing the term E (steam discharged or boiler evaporation per hour) in terms of the boiler heating surface or grate area. For the almost universal 45-degree seat the effective discharge area is, with a slight approximation ($L \times \text{sine } 45 \times \pi D$), in which L equals the valve lift vertically in inches and D the valve diameter in inches. Substituting this in the above formula gives $E = 47.5 \times L \times \text{sine } 45 \times \pi \times D \times P$, or $E = 105.5 \times L \times D \times P$.

The slight mathematical approximation referred to consists in multiplying the ($L \times \text{sine } 45$) by ($\pi \times D$) instead of by the exact value ($\pi \times D$ plus ½ L). To find directly the effect of this approximation upon the above constant, the values for E L D and P from the tests have been substituted into the above formula and the average constant re-determined, which is 108.1. The average lift of all the tests is .111 inch. Plotting the constants obtained from the above formula in each test, as ordinates, to valve lifts, as abscissae; obtaining thus the slight inclination referred to in condition 6, and plotting a line with this inclination through the above obtained average constant 108.1, taken at the .111 average lift gives a line which, at a maximum lift of say .14 inch gives a constant of just 105. At lower lifts this is slightly larger. Hence 105 would seem to be the conservative figure to adopt as a constant in this formula for general use, giving

$$E = 105 \times L \times D \times P.$$

This transposed for D gives:

$$D = .0095 \times \frac{E}{L \times P}$$

Note that the nominal valve *area* does not enter into the use of this formula and that if a value of 12, for instance, is obtained for D it would call for two 6-inch or three 4-inch

SAFETY VALVE CAPACITY TESTS.

Run at the Stirling Works of the Babcock & Wilcox Co., Barberton, Ohio, November 30 to December 23, 1908.

Test No.	Duration of Test.	Size and Type of Valve.	Adjustment Remarks.	Valve Lift, In.	Pressure, Lbs. per Sq. In.	Superheat, Deg. F.	Discharge: Per hour, Lbs. of Steam.	Discharge: Area,* Square In.	Remarks.
	hrs.								
6	3	4-in. R. F. iron stationary	Regular adjustment, exhaust piped	0.0695	151.7	43.6	5,120	0.623	No back pressure.
7	3	4-in. R. F. iron stationary	Regular adjustment, exhaust piped	.139	145.4	45.1	8,600	1.255	Back pressure 2 lbs.
8	3	4-in. R. F. iron stationary	Regular adjustment, exhaust piped	.180	135.7	49.2	11,020	1.704	Back presure 3 lbs.; maximum pressure; lift > depth of seat.
9	3	4-in. R. F. iron stationary	Regular adjustment, exhaust piped	1.045	149.4	41.9	7,290	.9400	Back pressure, 1 lb.
10	2½	3½ locomotive Tpye R	Regular adjustment, without muffler	.140	146.7	39.0	8,685	1.109	Tests 10 to 12, inclusive, with an open locomotive valve.
11	3	3½ locomotive Type R	Regular adjustment, without muffler	.070	152.5	38.0	4,610	.5493	
12	3	3½ locomotive Type R	Regular adjustment, without muffler	.105	150.3	41.2	6,780	.8280	
13	3	3½ locomotive Type S	Regular adjustment, with muffler	.1395	146.3	38.1	8,400	1.106	Muffler valve in this and following locomotive tests.
14	2	3½ locomotive Type S	Regular adjustment, with muffler	.140	52.2	51.3	3,520	1.109	Test at low steam pressure.
15	2½	3½ with lipped feather	Regular adjustment, with muffler	.140	146.4	39.0	8,600	1.109	Different type of valve disc.
16	3	4-in. R. F. iron stationary	Regular adjustment, exhaust piped	.140	138.5	42.3	8,770	1.285	No back press.; rep. of test No. 7.
17	3	4-in R. F. iron stationary	Adjustment ring one turn 1/16-in. above regular position.	.140	142.	50.1	8,900	1.265	Back pressure, 3 lbs.; ring pos. changed.
18	2	1½-locomotive Type S	Regular adjustment, with muffler	.107	140.8	23.0	2,515	.4272	
19	1	1½ locomotive Type S	Regular adjustment, with muffler	.050	151.2	None.	1,550	.2038	Test 18-21, inc., unsatisfactory; valve too small for boiler used.
20	2½	1½ locomotive Type S	Regular adjustment, with muffler	.075	146.3	None.	2,025	.2560	
21	2½	1½ locomotive Type S	Regular adjustment, with muffler	.075	147.7	None.	1,975	.2560	
22	1¼	3½ R. F. iron stationary	Regular edjustment, exhaust piped	.070	146.8	42.6	4,320	.5493	No back pressure.
23	3	3½ R. F. iron stationary	Regular adjustment, exhaust piped	.140	139.9	43.9	8,360	1.136	No bk. press.; lift > depth of seat
24	3	3½ R. F. iron stationary	Regular adjustment, exhaust piped	.105	141.6	48.7	6,200	.8280	
25	3	3 R. F. iron-stationary	Regular djustment, exhaust piped	.130	140.1	48.4	6,370	.8846	Tests 24 to 27, inclusive, no back pressure.
26	3	3 R. F. iron stationary	Regular adjustment, exhaust piped	.100	142.8	45.6	5,160	.6770	
27	2	3 R. F. iron stationary	Regular adjustment, exhaust piped	.070	142.4	29.5	3,705	.4716	
28	3	3 locomotive Type S	Regular adjustment, with muffler	.130	128.4	48.7	7,000	.8846	
29	3	3 locomotive Type S	Regular adjustment, with muffler	.090	139.3	43.9	4,950	.6034	

* The valves all having 45 deg. bevel seats these areas are obtained from formula: $a = 2.22 \times D \times l + 1.11 \times l^2$; except where, as in test Nos. 8, 18, 23, 25, the valve lift is greater than the depth of the valve seat, where the following formula is used: $a = 2.22 \times D \times d + 1.11 \times d^2 + \pi \times D \times (l - d)$.
a = discharge area (sq. in.). D = valve diameter (in.). l = valve lift (in.). d = depth of valve seat (in.).

NOTE.—The four wings of the valve feather or disc probably reduce the flow slightly, but as these are cut away at the seat a definite correction of the exit areas for them is impossible. Further, the formula constants are desired for the valves as made.

valves. For flat seats these constants become 149. and .0067 respectively.

The fact that these tests were run with some superheat (an average of 37.2 degrees Fahrenheit) while the majority of valves in use are used with saturated steam, would, if any material difference exists, place the above constants on the safe side. The capacities of the stationary and locomotive valves, the lift test results of which have been summarized, have been figured from this formula, taking the valve lifts at opening and in pounds of steam per hour, are as follows:

Of the seven 4-inch iron body stationary valves, the average capacity at 200 pounds pressure is 7,370 pounds per hour, the smallest capacity valve (figured for a flat seat) has a capacity of 3,960 pounds, the largest is 12,400 pounds, and of the six 3½-inch muffler locomotive valves at 200 pounds pressure, the average capacity is 6,060 pounds per hour, the smallest 4,020 pounds, the largest 11,050 pounds.

To make the use of the rule more direct where the evaporation of the boiler is only indirectly known, it may be expressed in terms of the boiler-heating surface or grate area. This modification consists merely in substituting for the term E (pounds of total evaporation) a term H (square feet of total heating surface) multiplied by the pounds of water per square foot of heating surface which the boiler will evaporate. Evidently the value of these modified forms of the formula depends upon the proper selection of average boiler evaporation figures for different types of boilers and also upon the possibility of so grouping these boiler types that average figures can be thus selected. This modified form of the formula is

$$D = C \times \frac{H}{L \times P}$$

in which H equals the total boiler-heating surface in square feet and C equals a constant.

Values of the constant for different types of boilers and service have been selected. These constants are susceptible, of course, to endless discussion among manufacturers, and it is undoubtedly more satisfactory where any question arises to use the form containing the term E itself. Nevertheless, the form containing the term H is more direct in its application, and it is believed that the values given below for the constant will prove serviceable. In applying the formula in this form rather than the original one, containing the evaporation term E, it should be remembered that these constants are based upon average proportions and hence should not be used for boilers in which any abnormal proportions or relations between grate area, heating surface, etc., exists.

For cylindrical multitubular, vertical and water-tube stationary boilers a constant of .068 is suggested. This is based upon on average evaporation of 3½ pounds of water per square foot of heating surface per hour, with an overload capacity of 100 percent, giving 7 pounds per square foot of heating surface, the figure used in obtaining the above constant.

For water-tube marine and Scotch marine boilers, the suggested constant is .095. This is based upon an overload or maximum evaporation of 10 pounds of water per square foot of heating surface per hour.

For locomotive boilers, .055 is taken, this constant having been determined experimentally, as explained below. In locomotive practice there are special conditions to be considered which separate it from regular stationary and marine work. In the first place the maximum evaporation of a locomotive is only possible with the maximum draft obtained when the cylinders are exhausting up the stack, at which time the throttle is necessarily open. The throttle being open is drawing some of the steam and therefore the safety valves on a locomotive can never receive the full maximum evaporation of the boiler. Just what percent of this maximum evaporation the valve must be able to relieve under the most severe conditions can only be determined experimentally. Evidently the severest conditions occur when an engineman after a long, hard, up-hill haul with a full glass of water and full pressure, reaching the top of the hill, suddenly shuts off his throttle and injectors. The work on the hill has gotten the engine steaming to its maximum and the sudden closing of throttle and injectors forces all the steam through the safety valves. Of course, the minute the throttle is closed the steaming quickly falls off and it is at just that moment that the severest test upon the valves comes.

A large number of service tests has been conducted to determine this constant. The size of the valves upon a locomotive has been increased or decreased until one valve would just handle the maximum steam generation, and the locomotive heating surface being known, the formula was figured back to obtain the constant. Other special conditions were considered, such as the liability in locomotive practice to a not infrequent occurrence of the most severe conditions; the exceptionally severe service which locomotive safety valves receive; and the advisability on locomotives to provide a substantial excess valve capacity.

As to the method of applying the proposed safety valve capacity rule in practice, manufacturers could be asked to specify the capacity of their valves, stamping it upon them as the opening and closing pressures are now done. This would necessitate no extra work further than the time required in the stamping, because for valves of the same size and design giving practically the same lift this would have to be determined but once, which of itself is but a moment's work with a small portable lift gage which is now manufactured. The specifying of safety valves by a designing engineer could then be as definite a problem as is that of other pieces of apparatus. Whatever views are held, as to the advantages of high or low lifts, there can be no question, it would seem, as to the advantage of knowing what this lift actually is, as would be shown in this specifying by manufacturers of the capacity of their valves. As to the feasibility of adopting such a rule (which incorporates the valve lift) in statutes governing valve sizes, this would involve the granting and obtaining by manufacturers of a legal rating for their valve designs based upon their demonstrated lifts.

This paper has dealt with but one phase of the subject of safety valves, in order that its conclusions might be drawn more clearly. The apparatus and tests shown indicate that the lifts and capacities of different make valves of the same size and for the same conditions vary as much as 300 percent, and that there is therefore the liability of large error in specifying valves in accordance with existing rules and statutes because these rules, as shown, rate all valves of one size as of the same capacity, irrespective of the above variation. A simple rule, based upon an extended series of direct capacity tests, is given, which avoids this error by incorporating a term for the valve lift. Finally, the method and advantage of applying this rule in practice have been briefly indicated.

Convention Rates

Rates at the Sealbach Hotel, Louisville, Ky., for the annual convention of the International Master Boiler Makers' Association, April 27, 28, 29 and 30 are as follows: European plan, single room without a bath, $2 per day; two in a room, $3 per day; $1.50 extra for each additional person in the above rooms. Rooms with bath, one person, $3, $3.50 and $4; two persons, $4, 4.50 and $5. Anyone desiring American plan rates will find several first-class hotels within the radius of one or two blocks of the convention headquarters.

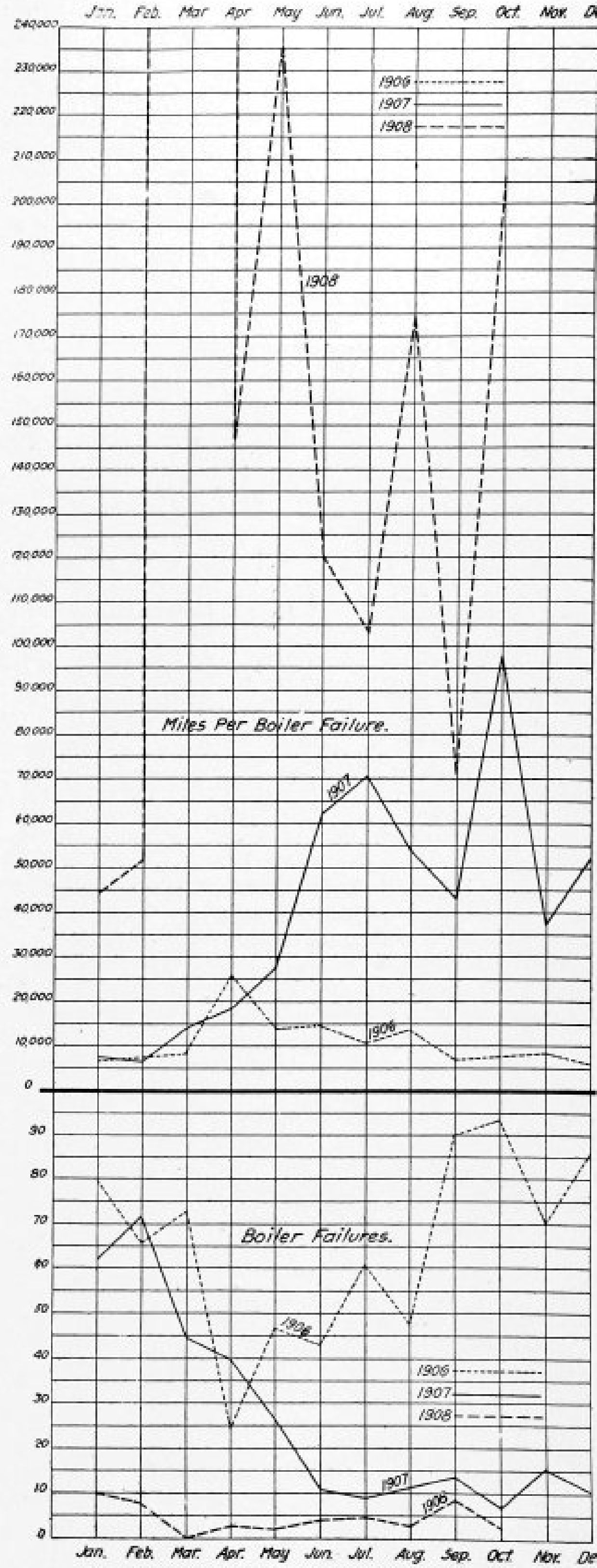
REMARKABLE REDUCTION IN BOILER FAILURES ON THE "SOO" LINE.

The accompanying chart shows graphically the record of boiler failures on the Minneapolis, St. Paul & Sault Ste. Marie Railway for the last three years—or to be exact, for 1906 and 1907 and for ten months of 1908. The chart is in two parts, one of which shows the total number of boiler failures for each month of the year, and the other the number of miles made per failure per month. It will be noticed that each chart falls into two parts, the division being at June, 1907, when there was a marked reduction in failures as compared with preceding months that has continued ever since. The low point was reached in March of the past year, when no failures occurred. This, of course, throws the peak of the "miles per boiler failure" for that month at infinity. It should be mentioned that these results were attained in spite of a boiler makers' strike which occurred last fall, and the filling of the places of the striking union boiler makers with non-union men, who on the average were less skilful and experienced than the men they supplanted.

We are informed by Mechanical Superintendent T. A. Foque that these results are due entirely to the use of a boiler compound which was begun experimentally in the spring of 1907. It was unknown in railway service prior to that time, and the trial on the "Soo" line was authorized with rather more than the usual amount of skepticism. A heavy decapod locomotive, which was running in the worst of the bad-water districts and giving more trouble than any other engine on the road, was assigned for the trial. The results were immediate and pronounced. Whereas this locomotive under the old conditions was costing several hundred dollars a year for boiler work, the expenditure for this purpose at the end of a year with the compound was just 26 cents, and the boiler was clean and in excellent condition.

The use of the compound was soon extended to all engines in bad-water districts with equally gratifying results in all cases. Fast passenger engines which had been sent to the shop for new fire-boxes shortly after the use of the compound was begun were treated with it instead of being repaired, and gave no further trouble, the fire-boxes being still in service. In the bad-water districts the fire-box mileage for passenger engines formerly averaged from 35,000 to 60,000 miles, and there was constant trouble on the road from the boilers, causing frequent delays to trains. Recently, on the hardest run, an engine had a credit of 125,000 miles, or about three times what it made under the old conditions. A number of new engines bought last year have made 80,000 miles, where ordinarily they would have made half this mileage, and from present indications a mileage of 100,000 to 125,000 is expected from the fire-boxes. In freight service, on one division, the heavy engines had a boiler failure for every 900 miles in September, 1906. In September, 1907, there was a mileage of 20,000 per boiler failure, and last year the same class of engines made 40,000 miles in September without a boiler failure. September, by the way, was the heaviest month in the history of the road; yet not only was the business handled promptly, but there was surplus motive power, repaired and ready for service, which was not needed. As might be expected, the roundhouse boiler work per engine has been considerably reduced and the back-shop work has benefited likewise.

There was at the start the usual prejudice on the part of employees against a boiler compound, and considerable work was required to get it properly used, but as soon as they realized fully what it was doing objections ceased, and they co-operated willingly to get the best results. Enginemen are as careful now to see whether the engine has its supply of compound before going out as they are to note whether it has water. The use of the compound has long passed the experimental stage, the permanency of the results on the "Soo" line being well shown by the chart.—*Railroad Age Gazette.*



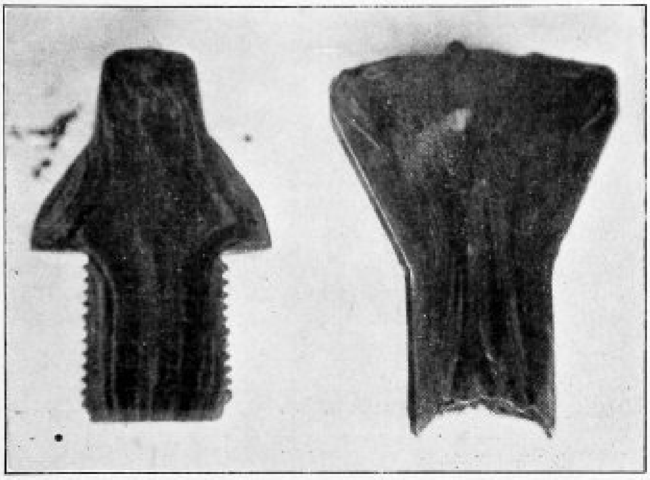
GRAPHICAL RECORD OF BOILER FAILURES ON THE "SOO" LINE.

THREADING CROWN BOLTS ON AN ACME STAY-BOLT CUTTER.

BY D. P. KELLOGG.

In bad-water districts on oil-burning locomotives, it is necessary to use some form of crown bolt which will offer as small an amount of exposed surface to the flame as possible in order to give satisfactory service. Figs. 1 and 2 show several crown bolts which have been sawed through the middle and the sections etched. No. 1 shows a crown bolt which was threaded into the sheet, but, as it was straight, the grain of the iron was cut in machining, as is very clearly shown by the etching. So much of this bolt was exposed to the fire that it did not give good service under the above conditions.

No. 2 is an etching of a forging where the collar was welded on to the bolt. The fracture shows that it was impossible to



No. 1. FIG. 1. No. 2.

make a good weld with the thin edges. This bolt was also wrong in construction, owing to the fact that the grain was not upset. Bolt No. 1 was properly made as far as the forging is concerned, but was spoiled by machining.

The bolts shown in Fig. 3 are of improper design, as too much metal was upset in too small a space. This laid the fiber of the iron over rather than upset it, so that the head pulled off, as indicated in the etching.

Numerous other bolts, of which these are only examples, one of which was of the patch bolt variety, with as little sur-

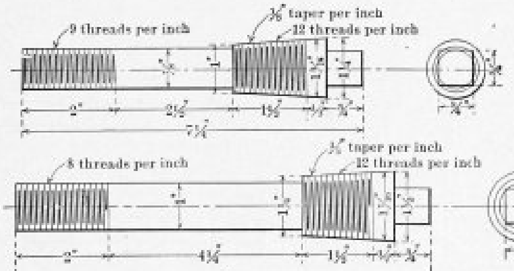


FIG. 2.—STANDARD TAPER CROWN BOLTS.

face exposed as possible, failed to give the desired results, so that the taper-threaded bolt was next resorted to. This has been found to give satisfaction, although it is a little more expensive to apply than any bolt which has yet been tried for this service.

The drawing, Fig. 2, shows the taper-threaded bolt as designed and applied. These bolts have now been adopted as standard on the Harriman lines.

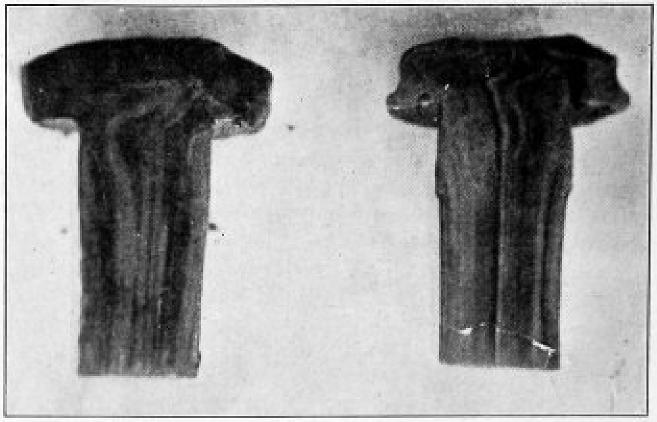


FIG. 3.

The application of these bolts involves three operations, namely: drilling the hole, reaming with a taper reamer, and tapping out the hole. Air motors are used to ream and tap and a sleeve is secured to the tool, so that the correct taper is obtained and the bolts may be cut off to the required length.

Fig. 4 shows an attachment applied to the bolt cutter for nicking the bolts to the desired length. After the adoption of this type of bolt, it was found desirable to get up some method of cutting them correctly and cheaply. This problem was solved by Mr. Harry Neville, foreman of the tool room at the

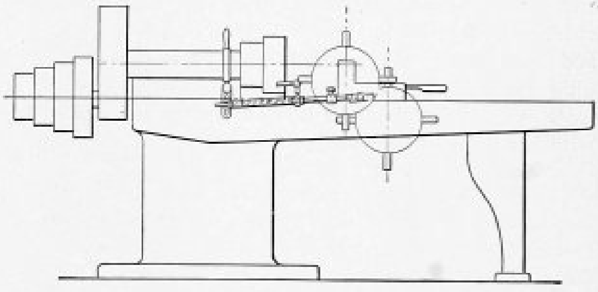


FIG. 4.—ACME STAY-BOLT CUTTER WITH TAPER ATTACHMENT APPLIED.

Los Angeles shops. His method consists of applying to an Acme bolt cutter an attachment which consists of mechanism to automatically open the die to the desired taper as the bolt advances into the machine. Details of this mechanism are shown in Fig. 5. With this attachment applied to the bolt cutter no extra time is required to cut the tapered thread, the amount of work the operator is required to perform being the same as if the thread were straight. The attachment has proved so successful that it is now regularly supplied by the

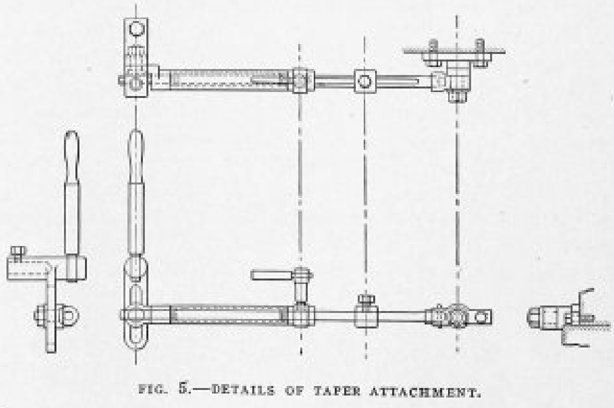


FIG. 5.—DETAILS OF TAPER ATTACHMENT.

manufacturers of the Acme bolt cutter and is applicable to cutting any taper thread for crown bolts or for any other purpose.

THE GENERATION OF STEAM.

In England for some time past boiler engineering has settled into a groove. There have been times of storm and stress—storm and stress so violent, indeed, that it might have been thought that the very existence of the British Navy, to say nothing of mills, factories and electric-light stations, hung in the balance; but sanity has returned to our counsels, and a few types of steam generator have established their claims to general adoption. The interest has shifted from the boilers to the furnaces—from the tool, so to speak, to the nature,

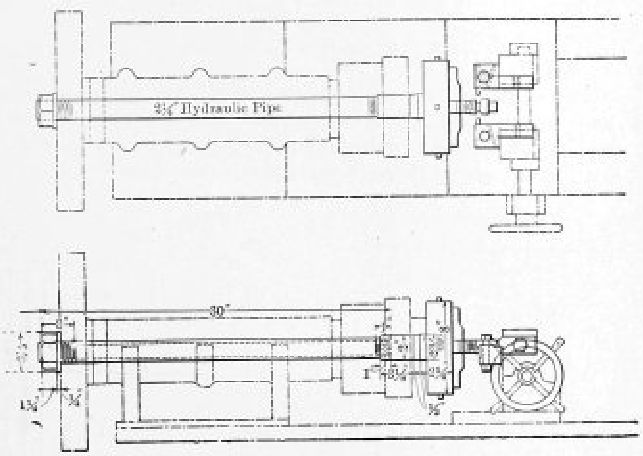


FIG. 6.—STAY-BOLT CUTTER APPLIED TO SCREW-CUTTING MACHINE.

method and kind of work done by that tool. The two factors of interest are the combustion of coal and the purification of feed-water. The unfortunate fact as regards the first is that the conditions of making steam and burning coal to perfection are in the main incompatible. At best they only admit of partial reconciliation. An army of inventors have been struggling after that reconciliation from the very beginning. It is questionable if much progress was made until recently. The purification of water is a simpler matter, and yet, as it can-

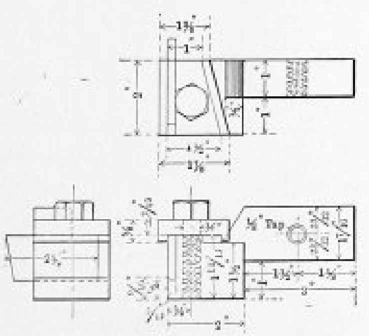


FIG. 7.—DETAILS OF CUTTER.

not be effected without outlay, it has not become as popular as it ought to be.

In the United States for some time back inquiries, exhaustive as far as they went, but limited in their range, have been in progress to settle, if possible, the best conditions under which coal can be burned. We have from time to time dealt with these inquiries, which have been carried out by a committee of the United States Geological Survey. The general results can be easily stated here. Almost any kind of coal can be burned in a way to get the most power out of it without smoke, by using a chain grate, a continuous feed, a long brick arch, and proper means of regulating the admission of air. In all this there is nothing complex, expensive, or demanding extra skill on the part of the fireman. We have in effect a development of the old Jukes traveling grate. It is unfortunately difficult to secure the requisite furnace capacity with any but water-tube boilers; and there is very little "elasticity" about the firing—that is to say, the velocity of the grate, the thickness of the bed of fuel on it, and the amount of the draft being once fixed, any change may do harm. The system does not apply well to boilers which are at one period worked very easily and at another are driven as hard as they can go. Unfortunately, this is just a condition that must be provided for in many cases; it is normal in most generating stations.

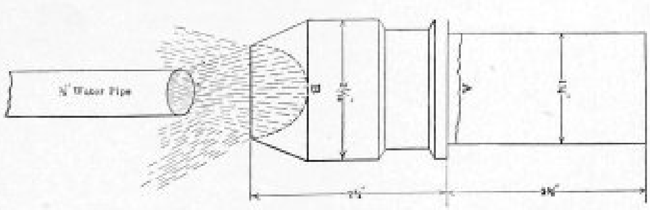
The burning of coal is a very simple matter, and presents no difficulty. The burning of the gas which is produced during the combustion of the coal is the source of trouble. The products of combustion consist of gases distilled from the coal, with nitrogen, and now and then a little free oxygen. There is also usually a great deal of steam, at all events at the top of the chimney, tending to augment the apparent volume of the smoke. The burning of a gas consists in its combination with oxygen at a high temperature. If, on the one hand, the temperature is too high, this combination will not take place. According to some recent authorities the perfect combination of carbon with oxygen is impossible unless water vapor is present. Failing this we have C O instead of CO_2. In any case the operation takes times for its carrying out, and during that time the temperature must be kept up. If, now, the gas is caused to impinge on a comparatively cold metal, a result will be obtained precisely the same as that got by holding a cold plate in the flame of a candle. The questions to be solved are somewhat complex. What are the least space and time in which complete combustion can be effected? Are these spaces and times compatible with boiler efficiency? Is perfect smokeless combustion worth the price that must be paid to secure it?

The first question is by far the most interesting. It can, however, scarcely be regarded as quite distinct from the second. The object of the furnace designer is to keep the products of coal distillation as hot as possible. The object of the boiler designer is to take all the heat out of them in the least practicable time. A compromise must be effected. The attempt at effecting it is the apology for a multitude of patents. Curious physical problems meet us at every turn. It is, for example, possible to burn carbon in the form of coke, so that it will produce only radiant heat. Now, if we use a small fire-box, a very good percentage of that heat will be utilized in making steam. Let now the fire-box be much larger, the area of the grate remaining the same. Then, although the heating surface is more considerable, the production of steam will be less. What becomes of the radiant heat lost? No one can say certainly. When fuel is burned in a separate retort or chamber, and the products of combustion are then brought into contact with boiler plates, there is always a loss of efficiency unless the temperature of the gas is extremely high. This lack of temperature is one of the reasons why retort firing, as it has been termed, is so seldom satisfactory. It will be seen, then, that some definite relation must be maintained which complies in a way not clearly understood with maximum efficiency, a compromise being made between the rate at which the fuel is burned, the temperature, the proximity of the boiler surface, and the dimensions of the retort and the grate. It does not appear that any fixed rule can be laid down. It does appear, however, that the United States Geological Survey have been able to arrive at very satisfactory results by direct experiment, and they have shown, as we have said above, that indifferent bituminous coal can be burned to great advantage by combining a chain traveling grate, a long fire-brick arch, and a water-tube boiler. The unfortunate thing is that the conditions do not admit of being fulfilled in more than a comparatively small number of cases. It is, however, something to prove, as seems to have been done, that maximum steam production is not incompatible with the prevention of smoke—a point about which steam users as a body are somewhat skeptical.

The United States Geological Survey has not rested content with a consideration of the conditions favorable to combustion. Mr. R. B. Dole, a member of the staff, has made an estimate of the saving that may be effected by softening water used in the making of steam. He has taken as a basis 1,000 indicated horsepower, for which he has allowed 100,000 gallons daily. Taking the Mauwee as a typical American river, he shows that it contains 360 parts of impurities to the million, of which 105 are suspended mud, and the rest carbonate or sulphate of lime, with a little magnesium. In six working days 1,800 pounds of scale would be deposited in the boilers. He then gives calculations which he holds prove that an annual saving of £350 ($1,703) a year may be secured by softening the water, or about one-half the cost of the requisite plant. In drawing a comparison he does not seem to have made any allowance for the good that may be done by blowing down or scumming, but he does include the cost of boiler compounds in his estimate. It is not necessary to accept his figures as conclusive and yet perceive that much money is wasted by the use of hard water. The cost of softening it is not very great. Economy in this direction is "penny-wise-and-pound-foolish." There is, however, one consideration that is persistently overlooked by the apostles of water purification. It not infrequently happens that the wetted surfaces being deprived of a protective coating of scale, undergo rapid corrosion; while, in other cases, it has been said that flour deposit is formed with the most disastrous overheating results. In this, as in most other matters connected with the burning of coal and the generation of steam, caution, guided by experience, must be used to obtain an all-round satisfactory result. The chemist has always had a good deal to say about these things, for the most part quite useful. But it is well to keep in mind that the chemist has a way of looking at things which is very often not that of the man who pays the bills.—*The Engineer.*

Hardening Rivet Snaps.

There are but few ways of hardening rivet snaps for pneumatic hammers. First, if a snap is for any ordinary use it should be hardened, as is shown in the accompanying sketch, heating the entire tool to the hardening heat, then holding it directly over a small stream of water with plenty of force to it, being careful not to allow the water to strike any part of



METHOD OF HARDENING A RIVET SNAP.

the tool except the cap part at *B*. Hold over the stream and continue to cool until the shank is black, then polish and draw to the desired temper. If the hammer is to be put to the severest use then the tool should be treated as follows: Heat the entire tool to the hardening heat, place over a stream of water, as is shown in the sketch, except that the pipe should be under water to a sufficient depth to permit the submerging of the entire tool, thus hardening shank and all, but being careful to keep the stream of water entering the cap *B* until the tool is cool. Then take from the water and polish to draw. A hammer snap hardened in this way should always be drawn in lead, having the lead 700 degrees Fahrenheit, then place the shank of the tool in the lead up to the point *A*, leave in the lead until the cap *B* is drawn to the desired temper, then cool to check the temper.

A hammer hardened in this way, if properly heated, will be found in the following condition: There will be no trace of the shank ever being hardened when tested with a file, but if broken, the steel should be very fine and silky and be extremely tough; in fact, it will be in the best possible condition for a tool where a severe shock is continuous, as it is in the pneumatic hammer.—*James Steele in American Machinist.*

A Device For Layers Out.

The sketches show a stand for holding angle iron, tee iron and Z-bars while they are being laid out. This has proved a very handy device for the laying out bench, because usually in getting out angles there is one right and one left-hand bar to

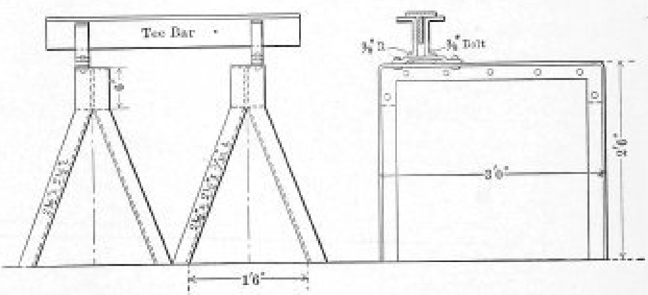


FIG. 1.—STAND FOR HOLDING BARS.

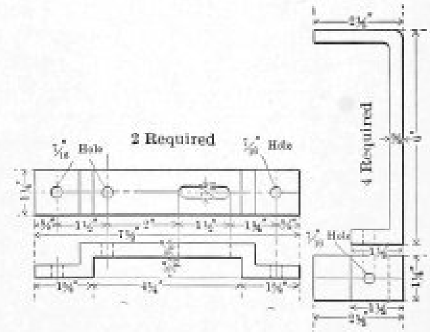


FIG. 2.—DETAILS OF CLAMP AND UPRIGHTS.

be laid out. The stand is very simple and can be easily made according to the sketch. It will be noted that the horse is made of angle iron, so that the stand can be bolted in place, giving no chance of a breakdown, such as might happen if the horse were made of wood. James H. Bondy.

Standardization.

The importance of standardization in boiler-shop work is evidenced by the fact that no less than three separate papers on various aspects of the subject are to be presented at the forthcoming convention of the International Master Boiler Makers' Association. These papers deal with the standardizing of blue prints for building boilers, the standardizing of shop tools and the standardizing of pipe flanges for boilers. Another paper which is to be presented might also be included under this important head, viz., that on rules and formulas. The establishment of definite rules and formulas is in itself an act of standardization.

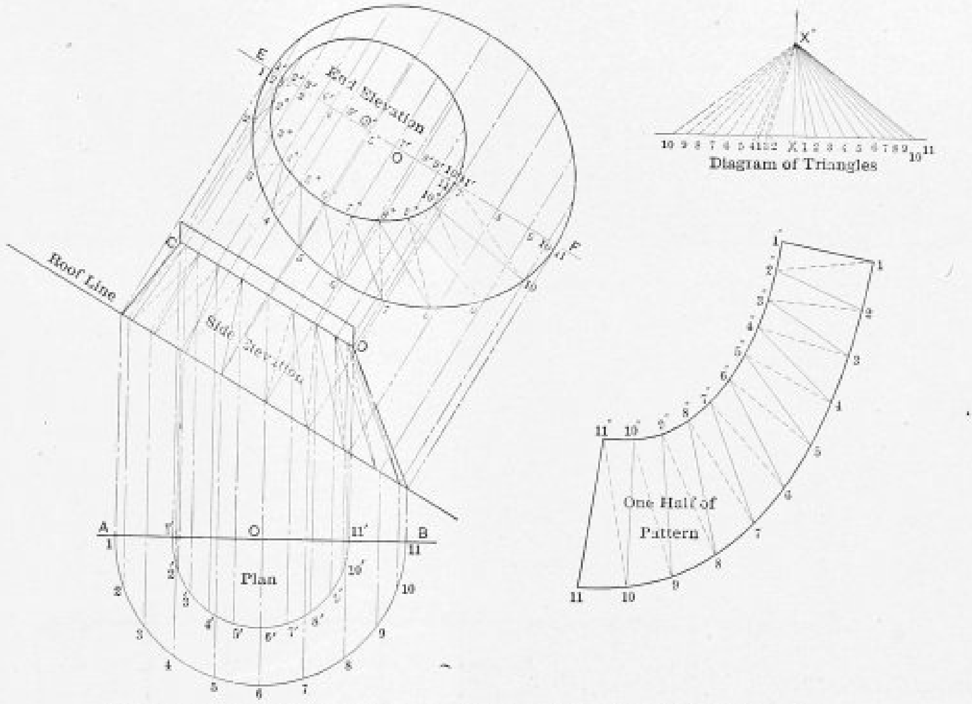
LAYOUT OF A SMOKESTACK COLLAR.

This collar, or rainshed, has the top cut parallel to the base or roof line, and the distance between the stack and the base of the collar is the same all around.

First, draw line *A B* in the plan. With *O* as a center describe two semi-circles representing the large and small bases. Divide the semi-circles into a number of equal spaces, each circle having same number of spaces. Next draw the roof line at the required angle, and set off the vertical height of the collar. Draw line *C D* parallel to the roof line. From points 1', 11' in the plan draw perpendicular lines to line *C D;* and from points 1, 11 in the plan draw lines to the roof line. From the point of intersection of these lines draw slant lines which form the side elevation. Now project points 2', 3', 4', 5', 6', 7', 8', 9' and 10' in the plan to line *C D;* at right angles to the small and another for the large oval, and to leave them set for further use. To construct the triangles, draw any line for a base line; erect the perpendicular and take the vertical height of the side elevation and set it off from x to x''. Next take the distance 1 1'' from the end elevation, and from x in the base line of the diagram of triangles scribe point 1 for the solid lines Now take distance 2 2'' and scribe point 2; transfer all the solid lines in the end elevation in this order, setting off each distance on the base line. From x'' draw solid lines, intersecting the small arcs on base line.

Now take the distance 1 to 2'', shown by the dotted lines in the end elevation, and set it off on the left from x to 1. Similarly take the distances 2-3'', 3-4'', 4-5'', etc., and draw the dotted lines, completing the diagram of triangles.

To develop the pattern, take the distance shown by the solid line x'' 11, draw a line on the pattern and set off points



ILLUSTRATING THE METHOD OF TRIANGULATION AS APPLIED TO A SMOKESTACK COLLAR.

this line and from the intersections draw lines as shown. Next take points 2, 3, 4, 5, 6, 7, 8, 9 and 10 in the plan and project them to the roof line, and from the intersections in the same line draw lines as before.

To construct the end elevation, first draw line *E F,* and with the trams set on points 6 and *O* in the plan, set one point of the trams on *O',* line *E F,* which is the center of the large base, and describe a small arc at 6. If a full view is wanted, strike an arc on the other side; next take distance 7 to line *A B* in the plan. With one point of the trams on 7', line *E F,* describe an arc, by stepping over to point 5' describe another arc. Take the remaining numbers, 8, 9 and 10, using line *A B* as a center in the plan; transfer to points 8-4, 9-3, 10-2, line *E F;* draw a curve through those points. Next take the distance 6' *O* in the plan, and on *O'* line *E F,* which is center for the small base. Describe a small arc at 6'. Next take the distance 7' to the line *A B* in the plan; set it off from point 7', line *E F,* to 7''. Step over to 5'; scribe point 5''; transfer points 8', 9' and 10' in same order as before, and draw the curved line, completing the end elevation.

Now divide one-half of the end elevation into a number of equal parts, and draw solid and dotted lines as shown on the drawing. It is advisable to use two pairs of dividers, one for 11, 11''. Next take the distance x'' 10'' (dotted line) and set it off from 11'' to 10 on the pattern. With the dividers already set from the large oval in the end elevation, from point 11 describe an arc at 10, intersecting that made from 11''. Now take the next distance x''-10 (solid line); set the trams on 10 and strike an arc at 10''. With dividers set from the small oval of the end elevation from point 11'' strike an arc at 10''. Next take the distance x''-9 (dotted line), and from 10'' scribe point 9; with the dividers set on 10 scribe point 9. Proceed in this manner until all the lines in the diagram are taken; then draw a line through the points, which can easily be done by bending a thin strip of wood on the points. Add for the flange on top to clamp the collar on to the stack, completing one-half of pattern.

In recent years wide fire-boxes with a corresponding reduction in the rate of combustion per unit area of grate surface have been largely favored. In general this has resulted in an increased economy in coal consumption, but in a greater number of boiler failures. A strong tendency is now being manifested towards the reinstatement of the narrow fire-box boiler, chiefly in order to reduce boiler failures.

JACOBS-SCHUPERT LOCOMOTIVE FIREBOX.

BY H. W. JACOBS.

Much effort and study have been expended upon the locomotive boiler to improve its efficiency in the generation of steam and to promote economy in its cost of maintenance. Many improvements have been made in its design and construction; yet no radical departure from early practice has been made since the locomotive reached its present general arrangement. Attempts at improvement have included a decided increase in size, a slight alteration of the general form, the occasional introduction of water tubes or the combustion chamber, and the widening of the water leg. The demand for greater tractive power has caused the enlargement of grate areas and the shape of fire-box sheets and wrapper sheets has been modified. In the main, however, the principles long ago established have been adhered to until the present.

Long experience and careful study of the prevailing design, however, has led to the decision that improvements can be made in the arrangement and construction, and that the following results can be obtained:

1. The maximum of strength due to the form without artificial support, such as from stays.
2. A greater strength with a reduction in thickness and weight of material.
3. An increase of circulation of the water inside.
4. An increase in the circulation of the gases outside.
5. An increase of transference of heat from the gases to the water per unit of surface.
6. A reduction of weight in proportion to steaming power.
7. A greater heating surface in proportion to weight.
8. A reduction of fuel consumed per effective horsepower.
9. A reduction of water delivered with the steam.
10. A reduction of heat delivered into the atmosphere.

The fire-box meeting these requirements has been designed, and three are now under construction in the Topeka shops of the Santa Fe Railroad. These boxes are being applied to what is known as the "Santa Fe type" engine, which is the largest engine in the world of rigid wheel-base design. This same type of fire-box is also to be applied to the new passenger Mallet type engines, which will be the largest locomotives in the world of any type.

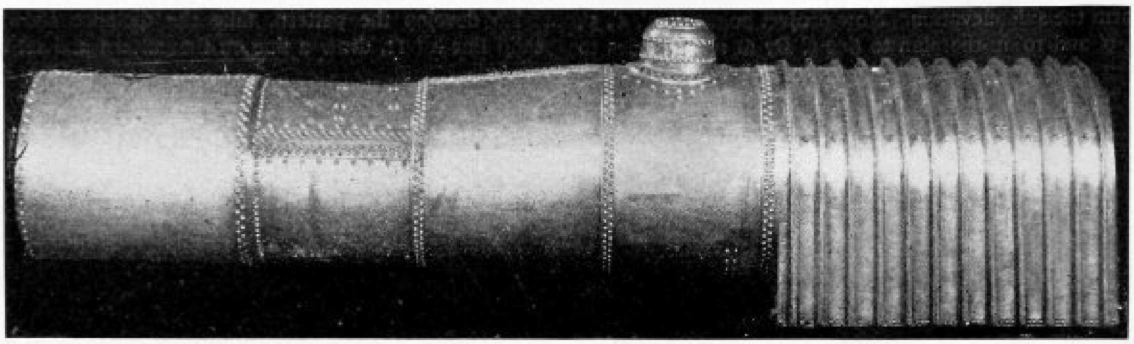
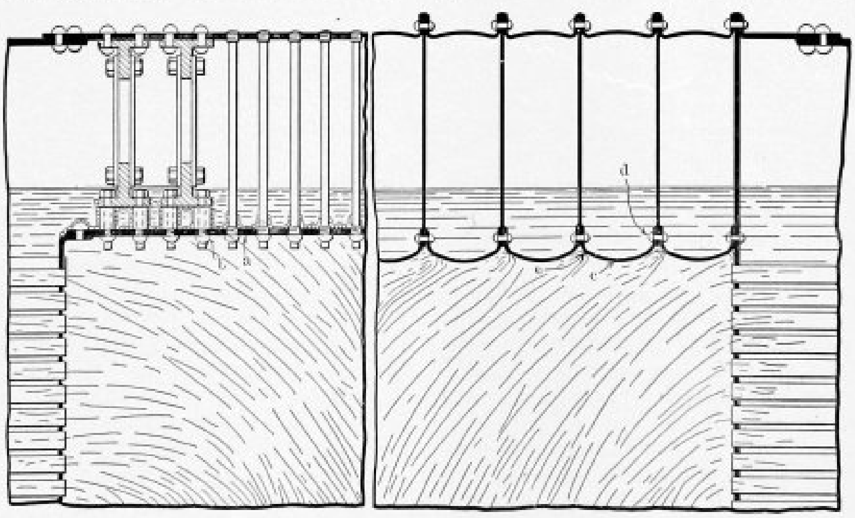


FIG. 1.—VIEW OF COMPLETED BOILER WITH JACOBS-SCHUPERT FIREBOX.

In this fire-box the usual arrangement of flat sheets supported by staybolts has been abandoned except in the front sheets and door sheets. Side sheets and wrapper sheet have been replaced by sets of channel-shaped sections riveted together with their flanges away from the fire. Staybolts have been replaced by stay sheets, one at each joint of the channels, which are interposed between the sections and secured by the same rivets that hold adjacent flanges. These sheets are partially cut away in the water leg, as shown in Fig. 3, to permit horizontal circulation of water around the fire-box and the edges of the sheets form calking strips for making tight joints between adjacent channel sections. All seams are submerged and no joints are exposed to the direct current of heat and gases. Due to the irregular outline thus formed for the fire-box crown and sides, the available heating surface of the hottest section of the boiler is enlarged without increasing the size of the grate area. A mud-ring of either the ordinary



Old Construction New Construction

FIG. 2.

type or a special design consisting of cast steel pockets may be used.

In the fabrication of this fire-box all the work is done by means of templets, jigs and formers, so that each one of the component parts is exactly like every other one, and all are interchangeable. This is achieved absolutely independent of the skill of the operators.

This construction presents many advantages over the usual design with very few counteracting disadvantages. The most striking features of advantage are:

SAFETY.

Due to its sectional construction this type of fire-box is less liable to violent explosions than the ordinary type. With the ordinary construction when there is a weak place in the sheet, the pressure causes the sheet to be torn at that point. The larger the fracture, the larger is the leverage and the pressure acting with this increased leverage will rip out large portions of the sheet before it is relieved. It is the sudden opening up of these large holes that causes the violent explosions. There is practically nothing to check a break in the ordinary fire-box sheet and, when it is once started, it is very liable to continue until much damage is done. In the sectional construction, however, it is impossible for a break to extend from one section to the other, and should a rupture occur in any section it will be simply a local break and cannot pass beyond the stay sheets to which the sections are riveted. The pressure will have no increased leverage to rupture the sheet in the original break, and consequently no violent explosion can occur.

NO LOCALIZED STRESSES.

The arched, pressure-withstanding, concave construction (Fig. 2-c) of the sections insures that there will be no undue and enormous local stresses due either to the pressure or induced by large differences or sudden changes in temperature at different points. The shape of each section is such that it will expand or contract with variations of temperature, and produce only small stresses on the adjacent sections. This is not true of the usual fire-box (Fig. 2-a). This sectional construction is specially adapted to relieve the excessive stresses that are set up in the ordinary construction by the local difference in temperature due to cold feed-water. When cold water is injected into the boiler, the temperature of the side sheet is very much reduced, and the effect is to contract the side sheet at its lower portion while it is expanded at its upper section. The forces induced by contraction and expansion, due to changes in temperature, are practically irresistible, and if no provision is made to take care of the contraction or expansion, there will be enormous local stresses set up in the metal.

Take, for example, a sheet 6 feet in length, and assume that its temperature is suddenly lowered by 200 degrees; the metal will contract until its length is reduced from 72 inches to 71.91 inches, or about .1 inch. If no provision is made to take care of this change in length, local stresses will be set up in the metal as great as 36,000 pounds per square inch. This is the value of the elastic limit of good steel and three times as great a pressure as should be used with safety under good conditions.

NO BURNED SEAMS.

All seams are submerged (Fig. 2-d), and thus are not subject to the danger of burning and leaking. The stay sheets between the channel and arch sections serve readily as calking strips.

LOW MAINTENANCE COST.

Due to the design, and also to the absence of staybolts and crown-bar bolts, the maintenance cost of the boiler should be very much lower than with present usual construction. The maintenance cost would be approximately something over 40 percent less than is now the case. As the cost of maintenance and renewals of fire-boxes, staybolts and flues amount to an approximate expenditure of $2,000,000 per year on a road having 2,000 locomotives, this fire-box should bring about a reduction of over $800,000 yearly in this expense.

USES THINNER SHEETS.

Owing to the absence of large local strains from unequal expansion and contraction (Fig. 2-c) the fire-box sections can be thinner than in the design with flat sheets and stays (Fig. 2-a); also owing to the absence of any side stay-bolts and crown-bolt heads (Fig. 2-b), the heat will be transmitted to the water more rapidly, and it will cause a greater evaporation

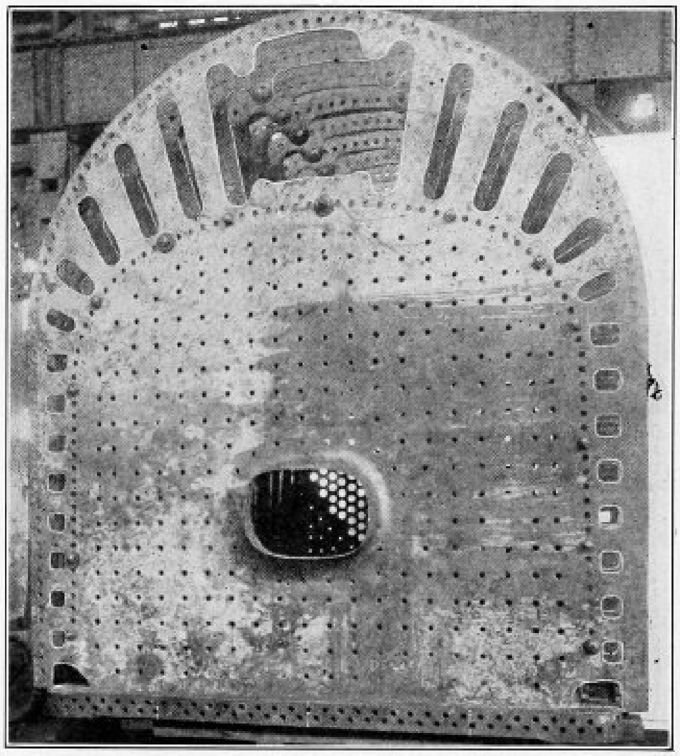


FIG. 3.—VIEW SHOWING WAY IN WHICH STAY-SHEETS ARE CUT OUT.

for a fire-box of the same grate area and heating surface, and per pound of coal burned.

It is a fact requiring no demonstration that heat flows from hotter bodies to cooler bodies. This transfer of heat, however, is not instantaneous, but continuous through a period of time. In two bodies of the same temperature no heat transfer takes place, and it is obvious that beginning with this condition, the transfer must be very slight and slow when one body is only a little hotter than the other.

The transfer of heat through metal is usually considered proportional to the difference in temperature of the two sides of the metal. The greater the difference in temperature, the greater the quantity of heat that passes through the metal in a given time.

"In the theory of heat transmission the assumption is made that the gas comes directly into contact with the metal surface of the boiler flue, and also that the water in the boiler absorbs the heat as fast as the metal can transmit it. In a commercially operated boiler neither of these assumptions is true. The metal of the boiler flue is insulated from the gas with a layer of soot, and from the water with a layer of scale and, perhaps, a layer of steam. As these layers of soot, scale and steam are very poor conductors, a resistance many times greater than that of the metal of the boiler tube itself is offered to the passage of heat. It is evident that under such conditions the difference of temperature between the first layer of gas and that of the first layer of water must be greater than it would have to be if the insulating layer of soot, scale and steam were not present, in order that the heat should flow from the gas to the water at a certain desired rate. This temperature difference must be larger the greater the required rates of heat transmission and the thicker the insulating scales. Inasmuch as capacity is the rate of heat absorption, this explains why at higher capacities the gases leave the heating surface of a boiler at higher temperatures than they do at lower capacities. It is clear, then, that in order to have the heating surface efficient it must be kept free from soot and scale, and the bubbles of steam must be removed from the surface as fast as they form, so that the water can come directly into contact with the metal. This last requirement emphasizes the importance of water circulation in the boiler. The faster the circulation of water the faster are the bubbles of steam carried away and the better is the contact between the metal and the water."*

The transfer of heat through irregular sections follows the same general law as just stated, but is more difficult to establish by experiment.

The transfer of heat through the crown sheet containing staybolts is rather more complicated. The surfaces in contact with the hot gases will be at a high temperature and the heat wave will tend to travel across the metal perpendicular to the surface. The staybolt head is curved and the heat energy tends to concentrate. A portion of the energy in its travel will strike the inner portion of the head in an oblique direction. Because of the contact of two metals heat is reflected back from this surface and tends to travel outward toward the head of the staybolt. The effect is that the whole surface of the head of the staybolt gets very hot, while the surface of the sheet is much cooler because its heat has been transmitted freely through the unobstructed metal. In case, however, the surface in contact with the water gets covered with a non-conductor and does not yield up heat freely, there is a tendency for the entire metal to get hot.

The transfer of heat through metal depends upon the action of the hot and cold bodies on either side of the metal. If there is a slow circulation, or no circulation, a small quantity of heat will be transferred. If the water circulates freely and rapidly, more water comes in contact with the surface in the same time and more heat is transferred.

If the heat is applied to the under side of a vessel containing water, the water will be rapidly heated. If the same heat is applied to the side of a vessel, the water will be heated very slowly. In the first case the heat is taken from the hot metal by convection or the bodily transference of the heat due to the motion of the heated water. In the second case, convection currents are not easily established and the heat is, for the most part, conducted through the water.

In a boiler the circulation is produced by convection, and it is of great importance to have a design that does not interfere with the water circulation in order to transmit heat.

In the ordinary type the crown bars are a great obstacle to the free circulation of water in a boiler by convection. Referring to Fig. 2 the path of a particle of hot water leaving the sheet is seen to be obstructed by the crown bars, which prevent free circulation and make the metal less efficient in transmitting heat.

In the other half of this figure it is seen that there is no obstruction to free circulation, and consequently there will be a high heat transference. In this type, the arched surfaces are more efficient in producing convection currents than the flat surfaces in the ordinary construction, due to the fact that less eddy-currents are set up.

* Report of Prof. Breckenridge on St. Louis boiler tests. United States Geological Survey.

LESS SCALE.

Since the water is generated into steam very much faster, we have very much better circulation. In consequence of better circulation, causing greater scrubbing action, and also due to the expansion and contraction of each unit, scale will not adhere to fire-box sheets.

HEAT ABSORBED FASTER.

The corrugations of the interior walls of the fire-box cause heat waves to be deflected into small addies (Fig. 2-e) on the sheets, thus giving the heat units more time to pass through the sheet into the water and also scouring the soot off the sheet.

LONGER LIFE.

There will be much longer life in the flue sheet and flues, as they will be subjected to less strain on account of the expansion and contraction being taken up by the corrugated sections.

FUEL CONSUMPTION REDUCED.

There should be a reduction in the amount of fuel used per unit of power developed, equal to 12 percent. This would appear either as a direct reduction in the total fuel cost, or as an increased gross ton mileage per ton of fuel consumed, and in either case the cost of fuel as a proportion of transportation expense would be reduced.

ROUNDHOUSE DELAYS REDUCED.

Detention of engines in roundhouses for boiler repairs should be so substantially lessened as to make engines available for service 8 to 16 percent more of their total time than at present, thus increasing the motive power available for traffic, and postponing the necessity for additions to this equipment.

[Editor's Note.—All the features of design and construction of this fire-box are fully covered by patents.]

A NEW FLUE CUTTER.

BY A. R. HODGES.

As shown by the illustrations, this flue cutter is operated by air. As usually applied, it is belt-driven, but it can be driven by an electric motor just as well. The machine does not stop after cutting off each flue, but the flue passes on through the machine and is taken out while another is being inserted. Three men are required to operate it, one to insert the flues, one to operate the machine, and one to extract the flues. The actual cutting requires only three seconds, so that the number of flues turned out in a given time depends entirely upon how fast one man can shove the flues in and another take them out.

A gas pipe runs through the two cast-iron hollow posts which hold the flue in position while it is being cut. This pipe is adjustable and can be raised or lowered or moved backwards or forwards, so that the flue will be cut the desired length. On the outer end of the gas pipe there is a little hinge with a tongue, so that when the flue is shoved into the gas pipe the tongue turns in, but after the flue has passed this tongue it falls back and becomes rigid. Then the operator shoves the flue back against the tongue and the machine cuts it off at the required length.

For cutting of safe ends there is an apparatus which the operator works with his foot. When he presses down on it the hook, shown in Fig. 2, moves upward and the flue can be shoved against it ready for cutting. As soon as the operator has the length of the safe ends which this apparatus produces, he removes his foot and it drops down out of the way and the safe ends are shoved out. Twenty safe ends can be cut per minute, and it is claimed that a nice, clean job is always obtained. One end of the flue, or safe end, is left

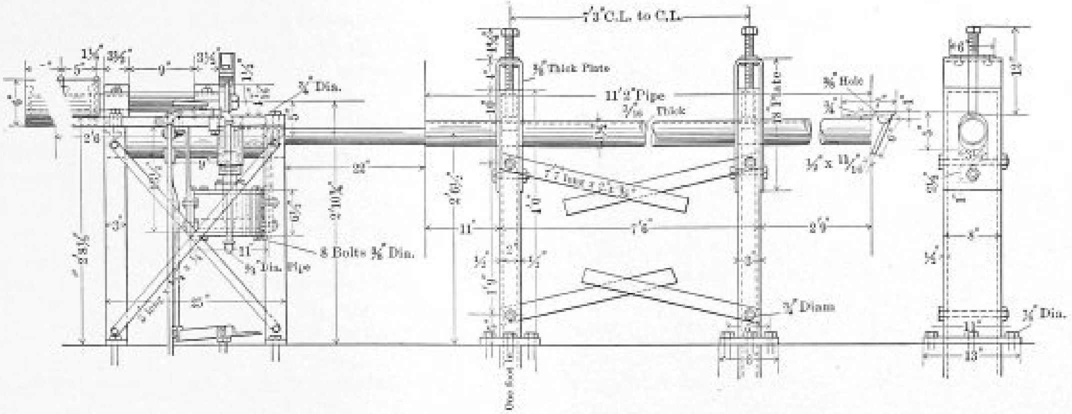


FIG. 1.—GENERAL VIEW OF THE HODGES FLUE CUTTER.

square, while the other is beveled slightly. It is never found necessary to grind the ends or square them up with an emery wheel.

It will be seen from the drawings that the machine is simply constructed and can be maintained at moderate cost. A machine of this kind is now being used with great success in the shops of the F. C. I. Railway of Mexico at Puebla, Mexico.

[EDITOR'S NOTE.—Patents for this device are pending.]

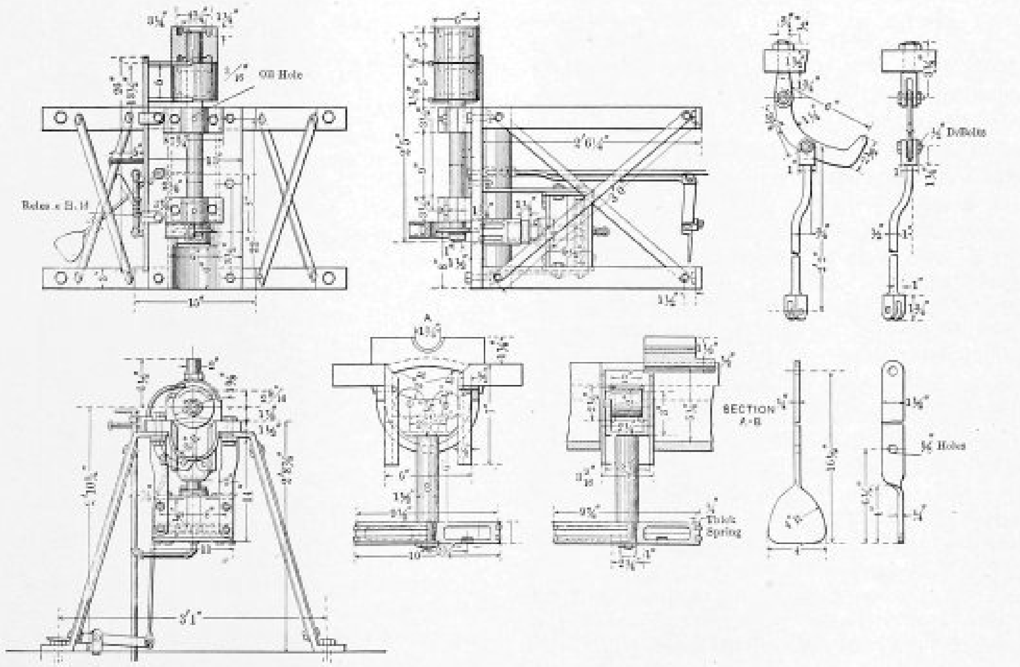


FIG. 2.—DETAILS OF THE HODGES FLUE CUTTER.

BOILER EXPLOSIONS DURING 1908.*

We present, herewith, our usual annual summary of boiler explosions, giving a tabulated statement of the number of explosions that have occurred within the territory of the United States (and in adjacent parts of Canada and Mexico) during the year 1908, together with the number of persons killed and injured by them. As we have repeatedly explained, it is difficult to make out accurate lists of boiler explosions, because the accounts that we receive are not always satisfactory; but, as usual, we have taken great pains to make the present summary as nearly correct as possible. It is based upon the monthly lists of explosions that are published in *The Locomotive;* and in making out these lists it is our custom to obtain several different accounts of each explosion, whenever this is practicable, and then to compare these accounts diligently in order that the general facts may be stated with a considerable degree of accuracy. We have striven to include all the explosions that have occurred during 1908, but it is quite unlikely that we have been entirely successful in this respect, for many accidents have doubtless occurred that have not been noticed in the public press, and many have doubtless escaped the attention of our numerous representatives who furnish the accounts. We are confident, however, that most of the boiler explosions that have attracted any considerable amount of notice are here represented.

The total number of boiler explosions in 1908, according to the best information we have been able to obtain, was 470, which is almost exactly the same as the number in 1907. There were 471 in 1907, 431 in 1906, 450 in 1905, and 391 in 1904.

* From *The Locomotive.*

When two or more boilers have exploded simultaneously we have followed our usual practice and counted each boiler separately in making out the summary, believing that by so doing we should represent the actual damage more accurately than we should if we simply recorded the number of separate occasions on which boilers have exploded. In some few cases two accidents have happened in the same boiler room on the same day. These have been counted separately in preparing the summary.

SUMMARY OF BOILER EXPLOSIONS FOR 1908.

MONTH.	Number of Explosions.	Persons Killed.	Persons Injured.	Persons Killed and Injured.
January	48	13	39	52
February	51	25	111	136
March	37	20	33	53
April	31	15	35	50
May	23	9	30	39
June	28	28	24	52
July	32	19	32	51
August	35	37	55	92
Septemper	39	21	36	57
October	55	27	49	76
November	45	45	53	98
December	46	22	34	56
Totals	470	281	531	812

The number of persons killed by boiler explosions in 1908 was 281, against 300 in 1907, 235 in 1906, 383 in 1905, and 220 in 1904; and the number of persons injured (but not killed) in 1908 was 531, against 420 in 1907, 467 in 1906, 585 in 1905, and 394 in 1904.

The average number of persons killed per explosion during 1908 was 0.598, and the average number of persons injured but not killed was 1.130.

TEN THOUSAND BOILER EXPLOSIONS.*

As readers of *The Locomotive* are well aware, we have made a practice for many years of recording in this journal the boiler explosions that occur in the United States and in adjacent parts of Canada and Mexico; and each year we also publish a summary of the explosions of the year preceding, giving the number of such explosions and the number of persons killed and injured by them. We began keeping these statistics on Oct. 1, 1867, so that they now cover a period of over forty-one years, and it is both instructive and impressive to look back over the record.

As will be seen by Table 1 the total number of boiler explosions recorded and briefly described in these pages, up to and including the present issue, is no less than 10,051. These have resulted in the death, either immediately or within a few days, of 10,884 persons, and in the more or less serious injury of 15,634 others; so that the total number of persons killed and injured by the explosions that have been recorded in *The Locomotive* is 26,518. These figures are worth more than passing attention, and we commend them particularly to those persons (for there are still such) who believe that boilers do not explode, or that they explode only rarely.

In preparing Table 1 we have revised all of the lists of explosions that have been published during the period that it covers; and we have made out new summaries for the years previous to 1879, not only for the purpose of detecting any errors that previous summaries may have contained, but also with the additional object of securing uniformity in the method of summarizing. In the early days, for example, explosions occurring in England, Germany, France and other distant parts of the world were recorded and included in the annual summaries, if they were of a serious character; but in later years we have omitted such explosions from our regular lists, mention of them, when mention has been given, being confined to separate paragraphs or articles. In preparing the tables given in the present article, foreign explosions have been omitted altogether, except (as noted above) those occurring near our borders, in Canada or in Mexico.

* From *The Locomotive*.

In looking over accounts of boiler explosions, we often find it said that "several" persons were injured; and for the purpose of summarizing the explosions during a given period it is necessary to estimate the probable number that the word "several" signifies when so employed. Some years ago we undertook to settle this point as definitely and fairly as possible, by studying those cases in which some of our accounts of a given explosion said "several" persons were injured, while other accounts of the same explosion gave the exact number, and we found that the average number of persons injured, when the account says "several," appears to be almost exactly three. In recent years we have therefore assumed that "several" means "three" when used in this way, and this interpretation has been given to it, in the earlier years as well as in the later ones, in making out the present revised summary of the explosions since 1867.

TABLE 1.—SUMMARY OF BOILER EXPLOSIONS FROM OCTOBER 1 1867, TO JANUARY 1, 1909.

YEAR.	Number of Boiler Explosions.	Number of Persons Killed.	Number of Persons Injured.	Total of Killed and Injured.
1867*	31	48	52	100
1868	101	226	185	411
1869	96	147	268	415
1870	109	213	272	485
1871	89	383	225	608
1872	98	232	235	467
1873	92	130	215	345
1874	98	175	160	335
1875	102	134	195	329
1876	75	147	145	292
1877	83	157	201	358
1878	97	178	216	394
1879	132	208	213	421
1880	170	259	555	814
1881	159	251	313	564
1882	172	271	359	630
1883	184	263	412	675
1884	152	254	251	505
1885	155	220	278	498
1886	185	254	314	568
1887	198	264	388	652
1888	246	331	505	836
1889	180	304	433	737
1890	226	244	351	595
1891	257	263	371	634
1892	269	298	442	740
1893	316	327	385	712
1894	362	331	472	803
1895	355	374	519	893
1896	346	382	529	911
1897	369	398	528	926
1898	383	324	577	901
1899	383	298	456	754
1900	373	268	520	788
1901	423	312	646	958
1902	391	304	529	833
1903	383	293	522	815
1904	391	220	394	614
1905	450	383	585	968
1906	431	235	467	702
1907	471	300	420	720
1908	470	281	531	812
Totals	10,051	10,884	15,634	26,518

* Last three months of year.

From the data given it appears that for the whole period of over forty-one years the average number of persons killed per explosion was 1.083, while the average number of persons injured (but not killed) per explosion was 1.555; the average number of of persons that were either killed or injured per explosion being therefore 2.638.

It is interesting to note the way in which the number of persons killed or injured per explosion has varied with the progress of time. This variation is shown very clearly in Table 2, in which the data given in the larger table have been summarized for four successive ten-year periods—the average number of persons killed and injured per explosion being given separately for each period. If we take the average number of persons killed, or the average number injured, as an indication of the seriousness of an explosion, Table 2 indicates that the boiler explosions of the country have been growing less and less serious—the change in this respect being marked and continuous. No doubt the tendency here indicated is in part real, owing to the improvement that has taken place in the design, construction and operation of steam boilers. We are of the opinion, however, that the progressive diminution in seriousness that is indicated so plainly by the last three columns of

TABLE 2.—COMPARISON BY TEN-YEAR PERIODS.

TEN-YEAR	Total Number of Explosions.	Total Number of Persons Killed.	Total Number of Persons Injured.	Persons Killed per Explosion.	Persons Injured per Explosion.	Persons Injured per Person Killed.
1868 to 1877*...	941	1,944	2,101	2.07	2.23	1.08
1878 to 1887*...	1,604	2,422	3,299	1.51	2.06	1.36
1888 to 1897*...	2,926	3,252	4,535	1.11	1.55	1.39
1898 to 1907*...	4,079	2,937	5,116	0.72	1.25	1.74

* Inclusive, in each case.

Table 2 is in considerable measure illusory, being due mainly to the vast improvement that the forty years have brought in our facilities for obtaining information concerning explosions. The collection of these statistics began, for example, only twenty-three years after Morse's first experimental telegraphic line had been erected; and the early part of the table is therefore concerned with a period in which the telegraphic news service of the country was exceedingly imperfect, and in many sections almost non-existent. Moreover, the Hartford Steam Boiler Inspection & Insurance Company was a very small concern forty years ago; whereas it is now a vast organization, having almost everywhere representatives who are all the time looking for information concerning boiler explosions. Bearing these two facts in mind, it is natural to conclude that in the early part of the forty-year period the smaller explosions escaped our attention in large measure, while the constantly increasing efficiency of the telegraphic news service, and the continued growth of this company, would cause explosions of relatively smaller "news value" to be noted and reported to our home office in the later years, so that the average seriousness of an explosion would appear to diminish with the progress of time, even if there were no such diminution in reality.

We do not consider that the falling off in apparent seriousness has been due in any appreciable measure to the increasing use of sectional boilers, for our experience has indicated that the bursting or rupture of such boilers is all too frequently attended with serious consequences in the way of killing or injuring the attendants. Moreover, the falling off in seriousness dates from a time when the number of such boilers in service was altogether too small to have any considerable effect upon the statistics of the country as a whole; and, finally, even if there were a real tendency towards decrease in seriousness, due to the gradual adoption of sectional boilers, we believe that this would be more than counterbalanced by the simultaneous tendency that there has been towards higher steam pressures and the use of larger boilers.

We are often asked whether boiler explosions occur with equal frequency at all times of the year, or whether there is any evidence that they happen oftener in some months than in others. As might be expected, there is no very pronounced variation in the number of explosions from one month to another, but yet the frequency does depend to a certain extent upon the time of the year. There is a sensible falling off in the number of explosions in April, May and June, and there is a corresponding increase in the number in October, November, December and January. This change is partially due, no doubt, to the explosion of heating boilers in our Northern latitudes during the colder months. It cannot be entirely due to this cause, however, for there is a decided falling off between January and February, notwithstanding the fact that February is perhaps as cold as January, so that between these months there would be no material reduction in the number of heating boilers in service, nor in the duty required of those in use. Also, it is plain that the increase in the number of explosions begins in the hot weather, the number of explosions in August being already greater than the average number per month for the whole year.

BOILER REPAIRS IN A ROUNDHOUSE.*

BY C. RICHARDS.

The number of roundhouse boiler repairs can be reduced by proper cooling off, washing out and refilling boilers with warm water, thereby saving the fire-box from cracking and breaking the stay-bolts. Leaky flues seem to be the most important of all roundhouse repairs, as they sometimes affect the steaming qualities of the locomotive as well as cause a loss of water. Engines which leak badly should have their flues expanded properly with a sectional expander, as this gives the most permanent job. Afterwards the job should be finished by calking the beads with a beading tool, as near standard as can be used. Roller expanders should be used as little as possible, as they roll the flue thin, greatly reducing its life. In some places the mandrel is used, but it should be used only when the time is short and there is no opportunity to use the expander. Leaky flues are sometimes caused by stopping up of the flues, and care should be taken to keep them clean by blowing them out with air. Calking the flues after a locomotive has been washed out sometimes saves expanding and final engine failure.

Leaky stay-bolts in the fire-box should be properly hammered up at the first sign of leaking, and if the sheet has started to crack they should be plugged, so as to avoid the trouble of patching, as roundhouse boiler makers have little time to patch or make heavy repairs. Stay-bolts should be tested from every thirty to sixty days by hammering on both ends of the bolt while there is steam or air pressure on the boiler. Steam pressure is preferable where the bolts have no tell-tale holes, as they are frequently installed now.

Patches on the fire-box do not wear as well as they should, because the engines are hurried through the roundhouse, and no more time is taken than absolutely necessary to calk them, so as to get the engine out of the shop dry. It is the writer's custom, if the patch is leaking badly, to let the water out of the boiler and calk the patch bolts and seam thoroughly, avoiding chipping as much as possible, as this shortens the life of the patches.

Leaky mud-rings come in for their share of work, as there are always a number of broken ones, and, if the cracks occur in the corners, it is almost impossible to calk them, or stop the leaks without taking the ring out and welding it. Mud-rings are sometimes plugged with copper, but this does not give satisfaction, as they leak continually while the engine is working; even patching the mud-rings does not give satisfaction. These are the most important of the many jobs with which a roundhouse boiler maker has to contend.

* A paper read before the Northern Railway Club, January, 1909.

Since the formation of the International Master Boiler Makers' Association three or four subjects have been brought up regularly at each annual convention, namely, flues, stay-bolts, firebrick arches and boiler explosions. The fact that there is always something new to be brought out and discussed regarding these subjects gives some indication of their importance to the boiler-making industry, and every one should come to the third annual convention, at Louisville, Ky., April 27 to 30, prepared to contribute some information which will help to clear up these questions.

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Pressure Tanks.

There seems to be a general impression that pressure tanks are not as dangerous as steam boilers, and that consequently it is unnecessary to use the same care in their construction and inspection as is used in the construction and inspection of steam boilers. Those who have followed Mr. McNamara's articles on the causes and effects of incrustation and corrosion in steam boilers and various pressure tanks, published in this and previous issues, will at once see the error of this belief. In nearly every case, tanks are more dangerous than boilers, especially such tanks as are used for digesters, driers, converters, and rendering tanks, on account of the presence of corrosive acids. In such tanks corrosion usually is heaviest along the seams and rivet heads, the rivet heads often being completely eaten away. Pipe fittings and all connections with the tank are also particularly liable to corrosion and frequently have to be replaced. The most dangerous element of this corrosion is apparently not its rapidity, but its deceptiveness, for it usually takes the form of uniform wasting away. The surfaces of the plates and rivets are apparently as good as new, but when the plate is drilled it is found to have been reduced in thickness to an alarming extent. It is naturally difficult under these circumstances for an inspector to determine the exact thickness of plate and consequent margin of safety. Pressure tanks are usually operated under a pressure of only 30 or 40 pounds per square inch, the boiler pressure being reduced by means of a reducing valve. There is always the possibility, however, that the reducing valve may fail to function, and the tank be subjected to the full boiler pressure. Safety valves and pressure gages cannot always be relied upon to give the proper warning, because the contents of the tank is usually some sticky substance which can easily obstruct either valves or gages.

There is no satisfactory way of protecting tanks against this corrosive action. Linings are sometimes used, but they are expensive to maintain and difficult to keep tight. The acids cannot be neutralized by an alkaline substance, as is done in the process of softening boiler feed water, because the acids are necessary products of the chemical processes which are being carried on inside the tanks. Practically the only way to insure the safety of these tanks is by frequent and thorough inspection by competent men. The workmen employed about plants where such tanks are used are frequently not possessed of sufficient technical knowledge to realize the dangers attendant on the operation of the tanks, and consequently every effort should be made to prevent the apparatus from becoming in a dangerous condition.

The Boiler Makers' Convention.

As already announced in previous issues of this magazine, the third annual convention of the International Master Boiler Makers' Association will be held at Louisville, Ky., April 27, 28, 29 and 30, with headquarters at the Sealbach Hotel. Papers will be presented upon the following subjects: Standardizing of blue prints for building boilers; boiler explosions; best method of applying flues; best method of caring for flues while the locomotive is on the road and at terminals, and the best tools for same; flexible stay-bolts compared with rigid bolts; best method of applying and testing same; steel versus iron flues: what advantage and what success in welding them; best method of applying arch brick; standardizing of shop tools; standardizing of pipe flanges for boilers and templets for drilling same; which is the long way of the sheet; best method of staying the front portion of a crown sheet of a radial top boiler to prevent cracking of the flue sheet in the top flange; rules and formulas; Senate bill.

We know of no opportunity which will be given to foremen boiler makers during the coming year to obtain a greater amount of information or more valuable help to them in their work than will be offered by the presentation and discussion of this large and varied list of important subjects. It will certainly be worth the sacrifice of the necessary time and money for any boiler maker to attend and take part in these meetings. The time of year and place of meeting are all that can be desired, and those who have charge of the arrangements for the convention are sparing no pains to make the occasion one of profit and pleasure to all who attend. It is to be hoped that the largest attendance ever recorded at a foreman boiler makers' convention will be the result.

Safety Valves.

At the 1908 convention of the Master Mechanics' Association a report was presented on the size and capacity of safety valves for locomotive boilers (see THE BOILER MAKER, September, 1908, page 283). In this report it was shown that it was practically a universal custom for railroads to specify the number and size of safety valves to be placed on their locomotives, basing their specifications almost entirely upon previous installations, that is, the number and size of safety valves placed on a locomotive boiler did not depend so much upon exact calculations proportioning the valves to the work which they were to perform as to precedent. Valves were specified entirely by their diameters, it being assumed that all valves of the same diameter had practically the same capacity, consequently the same effective area for discharge. This, however, was purely an assumption, which, in the light of subsequent experiments, is seen to have been false. The committee which made this report realized that there was not sufficient data to justify this assumption, and it suggested the necessity of finding out by direct experiments the sustained lift of various types of valves at different pressures. It also suggested that before putting much reliance upon a purely empirical formula for the size of safety valves, it would be necessary to measure accurately the amount of steam which flows through various types of valves at different valve lifts and steam pressures, because it is illogical to assume that Napier's formula for the flow of steam, which is only approximate for the flow through standard orifices, would necessarily apply to the irregular openings of a safety valve.

At the time the committee made this report one of the manufacturers of safety valves was engaged in making tests covering these points, and the results of the experiments have since been presented in a paper before the Society of Mechanical Engineers by Mr. Philip G. Darling (see page 89). The lifts of various types of valves were determined by attaching a rod to the top of the valve stem, connecting this rod to a lift-recording gage, and also to a lift-recording mechanism operated by a small motor, which recorded the lift on the card, also recording the time element. The flow of steam through the valve was ascertained by direct measurement when the valve was set at known lifts.

The results of these experiments place at our disposal some information which is somewhat startling. We have been accustomed hitherto when using the United States Inspectors' Rules to figure the size of a safety valve by assuming that the lift of the valve was 1/32 of its diameter. We now learn from Mr. Darling's experiments that the lift of different types of valves varies by as much as 300 percent. It is thus apparent at a glance that a formula for determining the size of safety valves, which does not include a factor for the actual lift or effective area of opening, is quite unreliable. Experiments were also made to determine the flow of steam through a valve, and it was shown that Napier's formula is a satisfactory measure of the amount of steam discharged, provided the coefficient is slightly changed, the new coefficient being 92½ percent of the former one.

On the basis of the information gained from these experiments, Mr. Darling proposes a new formula for the size of safety valves, in which the diameter of the valve is determined from an equation involving the weight of the steam discharged or the evaporation of the boiler per hour, the lift of the valve, and the absolute steam pressure. For the sake of simplicity this is further modified by substituting for the weight of steam discharged per hour a term involving the total heating surface of the boiler. This, of course, necessitates the arbitrary choice of certain constants, showing the relation between the total evaporation of the boiler and its heating surface for different types of boilers. If these constants are carefully chosen, the formula becomes very simple and is readily applicable.

The demonstration of the liability of large error by specifying valves according to existing rules and data, shows the importance of revising such rules to correspond with the more accurate means which are now available for determining the size and capacity of safety valves.

TECHNICAL PUBLICATION.

Practical Sheet and Plate Metal Work. By E. A. Atkins. Size, 4¾ by 7 inches. Pages, 491. Illustrations, over 400. New York, 1909: The Macmillan Company. Price, $2.00 net.

This book contains forty chapters, treating of almost every conceivable form of sheet metal and plate work. Only a few of these chapters, however, are of immediate interest to boiler makers, because by far the greater part of the book is taken up with a discussion of light sheet metal work, such as roofing and the manufacture of small, irregular-shaped articles. No information is given regarding boilers, but part of the book takes up the subject of tanks and piping, and this should be found particularly useful to boiler makers who are required to lay out a variety of work. Although most of the book treats of smaller work than is handled in the boiler shop, yet the principles of geometry set forth in the development of the various articles described are identical with the principles which a boiler maker must know. It is, of course, essential that every workman who is to become a proficient sheet or plate metal worker should have at least a fair knowledge of practical geometry, mensuration and the properties of metals. These subjects are treated in this book from the point of view of their application rather than as separate and distinct subjects.

The order in which the various subjects are taken up is as follows: Elbows; bends and intersections of round pipes; square and rectangular pipes; development of hoods; flat-sided tapered articles; boxes, fenders, etc.; conical articles; irregular tapering articles; elliptical work; roofing work; ventilators, hoppers and hollowed articles; various pipe bends, handles, brackets and other double curvature work; sheet metal joints; riveted joints; surface treatment of metals; metals and their properties, and mensuration rules.

PERSONAL.

P. J. CONRATH, formerly master mechanic of the Missouri-Pacific Railroad, has accepted a position with the National Tube Company.

OLIVER WEIGLE has been made master boiler maker of the Chicago Great Western, at Oelwein, Ia. Mr. Weigle was formerly with the C., H. & D., at Moorefield, Ind.

E. H. HOEHENSTEIN has been appointed general boiler inspector of the Rock Island lines, with offices at Horton, Kan., vice W. B. Embury, appointed master mechanic at Chickasha, Okla.

W. B. EMBURY, who for the past two and a half years has been general boiler inspector of the Rock Island lines, was appointed on March 1 master mechanic of the Oklahoma & Pan Handle divisions, with headquarters at Chickasha, Okla.

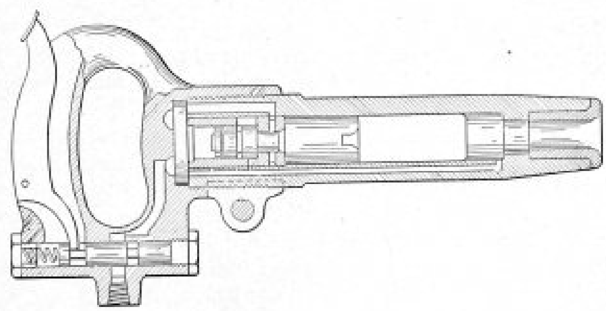
ANGUS MACLACHLEN and W. L. EVANS, who were formerly connected with the Dover Boiler Works, at Dover, N. J., have recently established a boiler shop of their own at Bartley, N. J., which is well equipped for handling all kinds of boiler stack, tank and structural steel work.

ENGINEERING SPECIALTIES.

Helwig Pneumatic Hammer.

The Helwig pneumatic hammer shown in the accompanying illustration is designed to meet the demand for a pneumatic hammer of large capacity, simple design and substantial construction. It is said to be one which is convenient to handle, easy of operation and low in cost of operation and maintenance.

The valve, of piston type, is balanced and has a large wearing surface. It is made of solid tool steel, hardened and ground, and as it operates in the same direction as the piston, the wear on it is claimed to be reduced to a minimum and the full power of the air is utilized for effective work. The one-piece valve chamber, also hardened and ground, is embedded firmly in the barrel to prevent its being displaced while the



hammer is in use and at the same time being readily removable for inspection or repair. The piston is a solid piece of tool steel, also hardened and ground. The drop forged steel handle is of the closed type. The hose connection is located at right angles with the barrel on the lower side of the handle and so placed as to be of the least hindrance to the operator. This is claimed to make a considerable saving in the wear and tear on the hose, as well as the threaded connection to the handle. A simple locking device is provided to prevent the handle from working loose.

The hard, metallic blow is said to be absent in this hammer and the ease of operation, in consequence of this fact, greatly lessens the fatigue of the operator. The rivet hammer made by this company is designed to deliver a sharp, powerful and speedy blow. The chipping hammer, of faster cutting speeds than the other hammers, may be regulated as to speed and weight of blow. It is claimed that a 4-inch stroke chipping hammer, used for riveting, will drive ¾-inch rivets steam tight.

The Helwig Manufacturing Company, St. Paul, Minn., are the manufacturers of this hammer.

The Scully Oil-Gas Rivet Heater.

This heater is equipped with a gas-generating burner, which successfully gasifies the oil before it is admitted to the combustion chamber of the forge; using any of the crude or fuel oils with equally satisfactory results. The burner consists of a spraying valve, which terminates in a heavy cast-iron disc nozzle honeycombed with perforations. This disc on being heated gasifies in the interior the oil which burns at the surface of the burner. The burner is circular, and covers the whole top of the forge, reflecting down on the bottom of the forge chamber a soft, uniform heat, which is capable of being regulated to any desired intensity. Any residue or deposit which may accumulate in the burner is easily removed by shutting off the oil flow for a few seconds and reducing the air flow, allowing the flame to burn back in the generator. The oil is burned, giving a blue flame similar to that given by the ordinary artificial gas, and there is no flashing of the flame out of the opening. The chamber is lined with special fireclay tile, which may be replaced at a nominal figure.

The arrangement of the forge is such that about 100 pounds of rivets, of the same or different sizes, may be held in the three hoppers located on the sides of the forge, as shown,

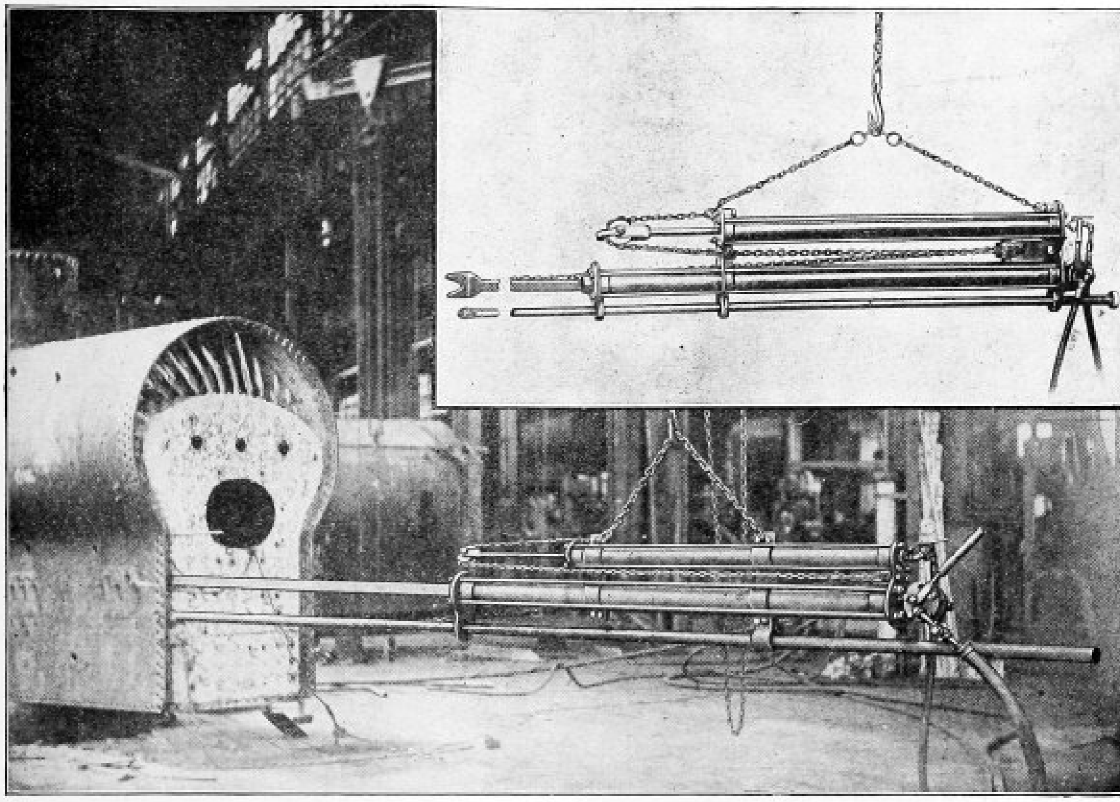
which fall into the heating chamber as they are removed from the hearth, making it a continuous-feed forge. The rivets in the three hoppers are gradually heated as they work down to the fire pot.

The heating chamber is 15 inches in diameter and 5 inches high. From 1 to 1½ gallons of oil are required per hour, and about 20 cubic feet of free air per minute, at pressures ranging from 40 to 100 pounds per square inch. The total weight of the heater is 450 pounds. It is manufactured by the Scully Steel & Iron Company, Chicago, Ill.

The Lowe Staybolt Cutter.

The difficult, tedious work of cutting out staybolts to remove fire-boxes from locomotive boilers is one of the most disagreeable and expensive operations in railroad repair shops, when done with the crude tools which are still largely employed for it. The pneumatic machine here illustrated, which is designed to break staybolts preparatory to removing fire-boxes from boilers and to cut bolts and rivets in dismembering steel bridges and buildings, was invented by Grover S. Lowe, a machinist in the shops of the Chicago, Rock Island & Pacific Railroad at Silvis, Ill., where for more than a year one of these machines has been in almost constant service, with satisfactory results.

The machine consists of two parallel cylinders securely joined together with a valve attached to the rear end of each cylinder. The valve on the shorter cylinder serves merely as a cut-off lock, with vent ports in one side of the housing or case, while the valve at the back of the longer cylinder is a special quadruple acting valve and constitutes one of the special features of the machine. Fitted in the long cylinder is a 100-pound striker sledge, which drives the cutting bar. The rear end of the latter is reinforced with a welded boss to with-



stand the blow. A hose carrying compressed air is attached to each cylinder. By means of a chain and shieve the piston of the short cylinder is made to hold the machine firmly against the cutting bar, forcing the latter up solidly against the bolt; in this manner the cutting bar is moved forward, automatically, taking up slack as the bolt yields in breaking. The valve on the long cylinder is so constructed that by moving the handle in one direction a large port is opened, admitting compressed air behind the striker, driving it forward with great force against the striking end of the cutting bar.

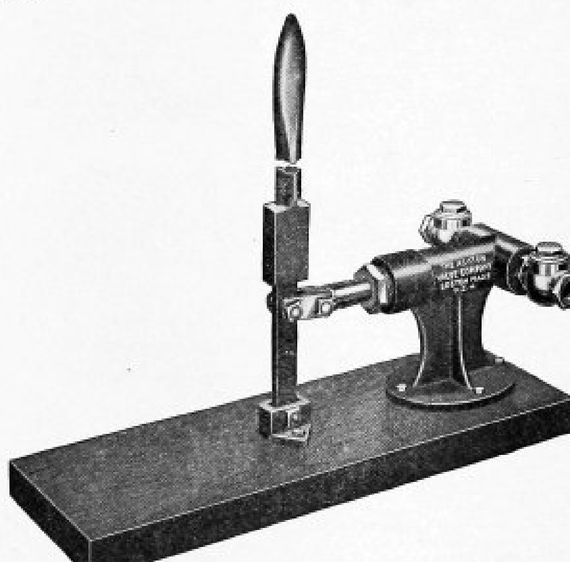
Both cylinders are 4 inches in diameter, the upper one being 5 feet 8 inches long and the lower one 7 feet 9 inches long, the length of travel of the breaker bar at one setting being 9 feet 6 inches. The machine works under air pressures of 80 to 150 pounds, doing best at from 100 to 125 pounds. A pressure of 100 pounds in the take-up cylinder brings a force of some 1,200 pounds against the bolt in addition to the blow of the breaker bar, assisting effectively in the work of the latter.

The machine is suspended from a crane or tripod, and may be conveniently applied to various operations, such as backing broken pins from engine drivers or other work where continuous heavy striking is required, and where a supply of compressed air is available. While simple in its construction and operation, the machine is said to render very efficient service. It is stated that 38 staybolts, 15/16 inch diameter, have been broken in 3 minutes and it is conservatively estimated that with one-third the help three times as much can be accomplished as by the old method.

This tool is manufactured by Williams, White & Co., Moline, Ill.

The Ashton Boiler Test Pump.

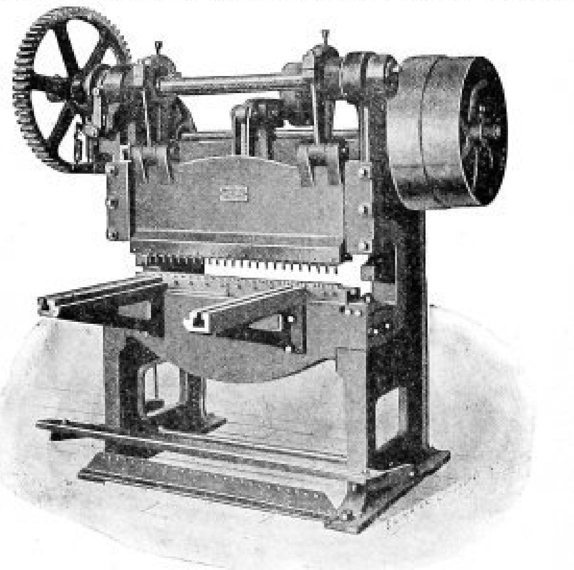
An improved boiler test pump is manufactured by the Ashton Valve Company, Boston, Mass., with a capacity up to 1,000 pounds pressure per square inch. The pump is of the plunger pattern, outside-packed, in order to do away with all troublesome cup washers. The piston is 1¼ inches in diameter, and has a 5-inch stroke. Perhaps the most valuable feature of the pump is the fact that it is made to work in a horizontal position, the pressure being easily obtained by means of a long, upright lever, which the workman can operate while standing in a natural position. The working parts are heavily constructed of Ashton high-grate composition, and the entire apparatus is mounted on solid wooden floor plate, readily portable.



These pumps should be particularly valuable for boiler inspectors, who must visit plants where it is not always possible to obtain hydraulic pressure. Boiler manufacturers will also find them useful, as they are less expensive than a steam-driven pump which would be installed for the same purpose.

A Gang Punch.

Bertsch & Company, of Cambridge City, Ind., manufacture a new gang punch in which the punches and dies can be arranged for either universal or independent adjustment. Each machine is provided with a stripper properly designed for the



particular work for which it is to be used. The machine is provided with the same automatic clutch which the manufacturers use on their heavy gate shears. This clutch has proved to be noiseless, positive and reliable in its action.

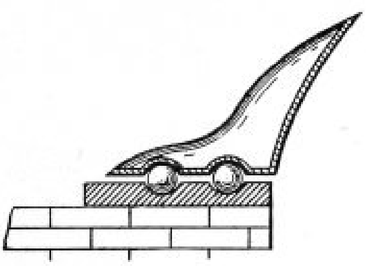
SELECTED BOILER PATENTS.

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

909,592. BOILER-LUG. MERTLAND M. HEDGES, OF CHATTANOOGA, TENN., ASSIGNOR TO THE CASEY-HEDGES COMPANY, OF CHATTANOOGA, A CORPORATION OF OHIO.

Claim 1.—In a boiler lug, a laterally projecting portion, and a plu-



rality of supporting balls for said laterally-projecting portion. Five claims.

908,122. WATER GAGE. JOHN O'CONNOR, OF CLIFTON, STATEN ISLAND, N. Y.

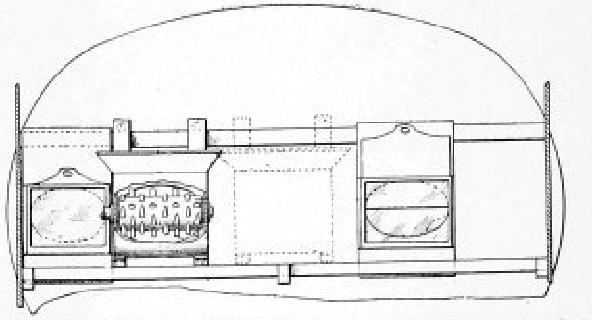
Claim 1.—A water gage comprising a transparent water tube, a tube-holding frame, a transparent shield disposed in front of the water tube, a shield holder fixed with respect to the said frame and separated by an intervening space from the water tube, and having rearwardly directed side flanges, a casing disposed alongside of and connected with the tube-holding frame, a reflector connected with the casing and extending back of the water tube, a transparent plate in the casing disposed toward the portion of the reflector back of the water tube, and an illuminating medium arranged in the casing. Three claims.

908,476. SMOKE-CONSUMING FURNACE. LUTHER A. MILBANK, OF BOSTON, MASS., ASSIGNOR TO ROBERT L. WALKER FURNACE COMPANY, OF BOSTON MASS., A CORPORATION OF MAINE.

Claim 2.—In a locomotive furnace, a fire-box provided with a grate, a water leg dividing said fire-box into compartments, a thrust bearing mounted on said water leg and provided with an inlet chamber and a discharge chamber connected with said water leg and with a discharge pipe, a swinging damper having a pivot co-operating with said thrust bearing, and having an internal axial inlet conduit communicating with said inlet chamber and communicating with a reflex damper passage, and having an axial return passage communicating with said damper passage and with said discharge chamber, there being a trunnion on said damper projecting through the rear water face of the boiler and co-operating with means to turn said damper to normally hold the same in engagement with said thrust bearing. Seven claims.

909,767. FURNACE. WASHINGTON T. DODGE, OF BELMONT, N. Y.

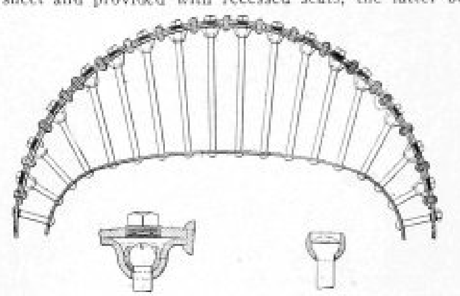
Claim 2.—The combination with a furnace having a door opening therein and a door slidably and removably mounted relatively thereto;



of a stoker movably mounted adjacent the furnace and outside of the door, said stoker being movable in one direction to shift the door, said door and stoker maintaining the door opening closed during the shifting of the door. Six claims.

909,956. STAY-BOLT FOR BOILERS. BENJAMIN E. D. STAFFORD, OF PITTSBURG, PA., ASSIGNOR TO FLANNERY BOLT COMPANY, OF PITTSBURG.

Claim 1.—The combination with inner and outer sheets, the outer sheet having threaded openings, of pads secured to the inner face of the outer sheet and provided with recessed seats, the latter being open



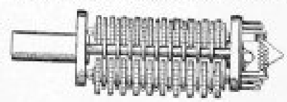
at their bottoms, bolts passing through the seats and having curved heads resting on the seats, the inner ends of the bolts secured to the inner sheets, and caps screwed into the openings in the outer sheet. Eight claims.

910,032. SMOKE-CONSUMING FURNACE. DAVID C. WALMSLEY, OF INDIANAPOLIS, IND.

Claim.—In a smoke-consuming furnace, the combination with a steam boiler, a furnace chamber, grates in said chamber and doors situated relatively to said grates so that the side half portions of the grates may be charged with fuel alternately, said furnace provided with hot air ducts formed in the side walls of the furnace, the inlet ends thereof situated beneath the grates and their outlet portions situated in a plane above the level thereof, caps extending over the outlet ends of said side ducts and provided with air outlet openings, said openings situated to direct the hot air passing therethrough toward the fire in the furnace chamber, of a bridge wall extending upwardly to connect with the bottom of the boiler of the furnace, hot-air ducts in said bridge walls having their inlet ends situated below the level of said grates and their outlet ends situated above the level of the grates, a partition wall situated in advance of said bridge wall to extend between the side walls of the settting of the furnace and upwardly to the boiler, a combustion chamber situated between said bridge wall and said partition, side flue ways situated on each side of said bridge wall connecting the furnace chamber with said combustion chamber and a lower flue way in said forward partition wall connecting the combustion and smoke chambers. One claim.

910,183. BOILER CLEANER. ANDREW H. DREIJER, OF BROOKLYN, N. Y., AND FREDERICK HAIGHT, OF SPARTANBURG, S. C.

Claim 1.—In combination with a rotating spindle having heads, shafts stationary in regard to said spindle and secured in said heads, centri-



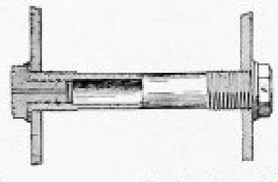
fugally operated cutters carried by said shafts, said cutters having perforations in their outer ends, shafts passing through said perforations, cutting disks carried by said shafts, and means for retaining one end of said shafts while the other end swings free, said means consisting of a perforated plate near the spindle head. Five claims.

910,305. FUEL FEEDER FOR FURNACES. DAVID F. NISBET, OF WILKINSBURG, PA.

Claim 3.—In combination with a furnace a fuel feeder comprising a hopper; a casing affixed to said hopper and communicating therewith; a hollow spindle centrally disposed in said casing and affixed at one end to the outer face of said casing and terminating at the opposite or inner end in the furnace chamber; a screw conveyer rotatably mounted upon the hollow spindle and provided with a ratchet plate at its outer end; a vibrating arm journaled upon the outer face or cover of the casing and provided with a pawl adapted to engage with the ratchet plate; means for vibrating said arm, and a notched or stepped plate co-operating with said arm for controlling the relation of the pawl with the ratchet plate. Eight claims.

910,361. STAY-BOLT FOR BOILERS. JACKSON DENEAL, OF TOLEDO, OHIO, ASSIGNOR TO JOHN BERTHELOT, OF EAST TOLEDO, OHIO.

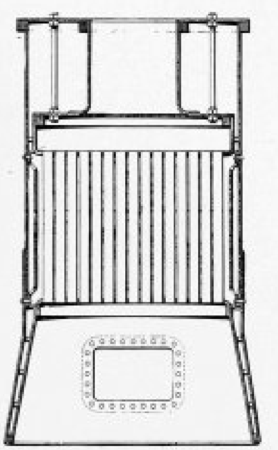
Claim.—A stay-bolt for boilers, comprising a main body bolt of a length to extend through alined orifices of opposite boiler plates, and having its end portions threaded, an attachable and detachable head bolt for each end portion of the bolt body, each head bolt having a threaded body portion of a length to extend through the adjacent boiler plate, and



adapted to threaded engagement with the threaded end portion of the main bolt body extending through the plate, and a head portion adapted to be engaged by a wrench, and to shoulder against the boiler plate through which its body portion extends, and a ductile metal washer on the body portion of each head bolt, adapted to be compressed between the head of the head bolt and the plate through which the head bolt extends, by running the head bolts into threaded engagement with the end portions of the main bolt body. One claim.

911,023. BOILER. VIOLA S. BEAN, OF MANCHESTER, N. H., ADMINISTRATRIX OF FRED S. BEAN, DECEASED.

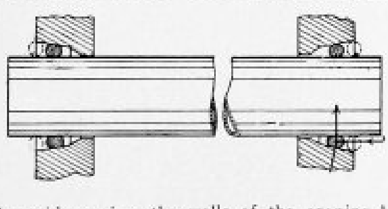
Claim 1.—In a boiler, a shell, upper and lower flue sheets therein, flues extending through the shell and connecting said flue sheets, and a false shell situated within the main shell, but separated therefrom, the



upper and lower edges of the false shell being situated in substantially the planes of the upper and lower flue sheets and being bent outwardly into contact with and secured to the main shell, said false shell having apertures formed therein near its upper and lower edges. Two claims.

911,156. TUBE JOINT. GUSTAV POLITZ, OF KATTOWITZ, GERMANY.

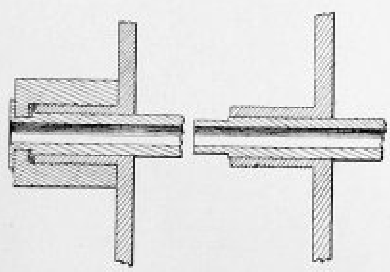
Claim 2.—A device of the character described comprising a tube plate having an opening therein for the reception of the tube and an elastic annular packing circular in cross section and encompassing said tube



and received by said opening, the walls of the opening being inclined from the outer surface of said tube plate inwardly and in a direction or line which if extended would intercept the axis of the opening and tube. Two claims.

911,397. MEANS FOR CONNECTING FLUES TO BOILER SHEETS. SAMUEL W. HOWELL, OF BROOKVILLE, IND.

Claim 1.—In combination, a boiler sheet having an opening and an integral boss extended outward from the sheet in line with said opening



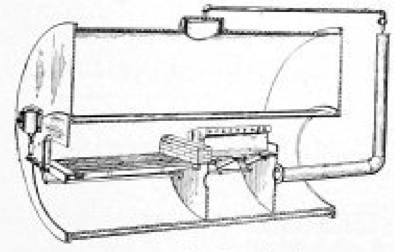
and exteriorly threaded, a flue fitted in said boss, and a nut threaded upon the said boss and having interlocking connection with the projecting end of the flue. Four claims.

911,333. BOILER-FLUE CLEANER. JOHN C. ROSS, OF EAST LIVERPOOL, OHIO.

Claim 1.—A boiler-flue cleaner comprising a nozzle, means for moving the nozzle across the ends of the boiler flues and means for supplying a soot-cleaning medium to different parts of the nozzle independently of each other. Six claims.

911,400. FURNACE. DENHAM JOHNSON, OF LONDON, ENGLAND.

Claim 1.—In a furnace, the combination with the fire-box, bridge-wall and rear structure thereof, of a plurality of super-heating chambers having open under sides and parallelly arranged one to the other and extending longitudinally of said furnace in the rear of said bridge-wall and having a plurality of outlets arranged at intervals in the side walls thereof towards the top and in the plane of the passing of the combus-



tion gases from said fire-box, a hot-air chamber arranged below and supporting said super-heating chambers and having openings in the top thereof communicating directly with the open under sides of said super-heating chambers and openings in the top thereof between and on each side of said super-heating chambers, a plurality of hinged valves covering said openings in the top of said hot-air chamber, and means for adjusting said valves to govern the supply of hot-air passing therethrough. Two claims.

911,473. FURNACE FOR STEAM BOILERS. GEORGE A. BUMILLER, OF PITTSBURG, PA.

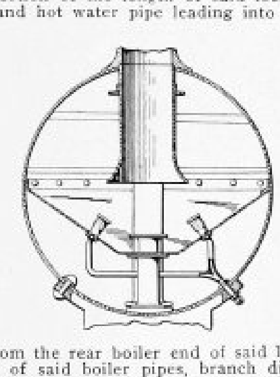
Claim 2.—In a furnace the combination with a grate, side walls each formed with a recess extending above and below the grate, of a supporting casting in each recess comprising a base portion located below the grate and an inclined portion extending from the base to the top of said casting arranged to form passages at the sides of the grate, said passages in communication with the ash-pit below the grate, and a grated casting resting upon each of the supporting castings and formed with a passage registering with the passage of its supporting casting. Four claims.

911,688. SMOKE-CONSUMING FURNACE. ROBERT L. WALKER, OF BROOKLYN, N. Y.

Claim.—In locomotive boiler furnaces, a fire-box provided with a grate, a water leg to divide said fire-box into compartments, a combustion arch at the front end of the fire-box to form a constricted passage around the front of said water leg beneath said arch, a thrust bearing mounted on said water leg, a pivoted damper mounted in said thrust bearing and having a trunnion projecting through the rear water face of the boiler, a roller bearing for said trunnion supported by and mounted close to said water face, a pinion on said trunnion, a bearing plate engaging said trunnion and loosely supported from said water face, an anti-friction bearing and thrust spring between said bearing plate and said pinion to hold said damper against said thrust bearing, a rack co-operating with said pinion, a steam operating cylinder and hydraulic cushioning cylinder substantially parallel to said rack, an operating piston having a piston rod projecting through both ends of said steam cylinder, a similar cushioning piston and piston rod in said hydraulic cylinder, cross-bars rigidly connecting said rack and said piston rods, steam connections comprising a three-way valve to operate said steam cylinder and piston, an adjustable throttling by-pass around said hydraulic cylinder, a circulating pump to positively circulate water from the cool part of said boiler through a staggered passage formed in said damper, and a damper outlet carrying said water back into the boiler. One claim.

911,817. SMOKE AND SPARK DESTROYER. GEORGE Z. GRAY, OF HARRISBURG, PA.

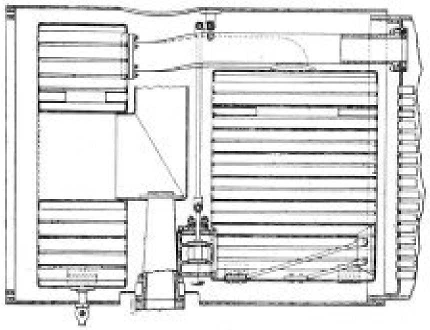
Claim.—In a smoke and hot spark preventing apparatus, the combination with a locomotive provided with a forwardly extended smoke box, having a frusto-conical frame of foraminous material fixed therein below the mouth of its smoke stack, of a conveying and mixing pipe extending a major portion of the length of said locomotive, a dry steam pipe and a steam and hot water pipe leading into the rear end of said



conveying pipes from the rear boiler end of said locomotive, regulating valves within each of said boiler pipes, branch discharge pipes leading from the forward end of said conveying pipe and projecting angularly through opposite sides of said foraminous frame, perforated nozzles threadedly engaged upon the upper projecting ends of said discharge pipes above said foraminous frame, and jam nuts threadedly engaged upon said discharge pipes, below and against said foraminous frame to lock said nozzles and said discharge pipes therethrough. One claim.

911,993. STEAM SUPERHEATER. HENRY W. JACOBS, OF TOPEKA, KAN.

Claim 1.—In a device of the character described, the combination, with a boiler having a smoke chamber and fire tubes opening thereinto, of steam superheating means comprising a plurality of separated sec-



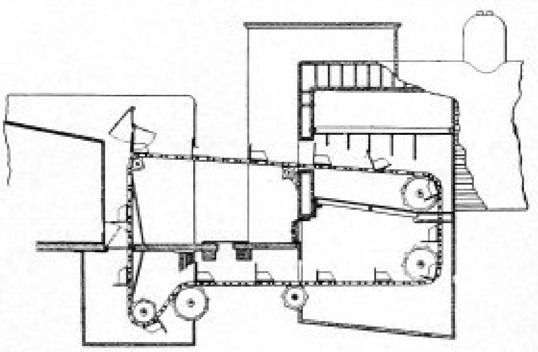
tions provided with fire tubes in said chamber, the fire tubes of said sections being in alinement with each other and with the fire tubes of the boiler, and said chamber having an outlet leading from between said sections. Sixteen claims.

912,201. SMOKELESS COMBUSTION FURNACE. ROBERT STOKER, OF SALT LAKE CITY, UTAH.

Claim 1.—In a smokeless combustion furnace having the usual fire-box and grate-bars separating it into a fuel chamber and an ash-pit, a hollow bridge wall adjacent the fire-box and having end passages and rear openings, a combustion chamber having an end spaced from the bridge wall and forming therebetween a mixing chamber, air induction conduits extending from the rear end of the furnace under the combustion chamber and the bridge wall to the ash-pit and communicating with the mixing chamber through the bridge wall by means of the said end passages, the side and front walls of the furnace having return flues formed therein and leading from the combustion chamber to the fuel chamber, and means for varying the area of the outlet from said channels to the ash-pit without varying the area of the outlet from these channels to the interior of the bridge wall. Two claims.

912,931. FUEL CONVEYOR FOR FURNACES. EDGAR ANDERSON, OF ALTO PASS, ILL.

Claim 2.—In a device, a fire-box having a door therein, an ash-pit provided with a similar door, a grate held between the fire-box and the ash-pit, provided with an opening in the back end thereof, a shaft in said fire-box above the grate opening, a second shaft in said ash-pit be-



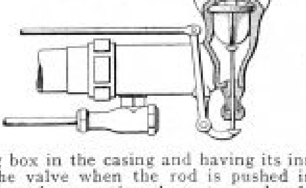
neath the first-mentioned shaft, and a conveyer arranged to pass through the fire-box door and over the first-mentioned shaft, down through the crate opening, beneath the shaft and the ash-pit, and out through the ash-pit door. Six claims.

912,561. DEVICE FOR THE CONSUMPTION OF SMOKE IN FURNACES. ANDREW GROPENGIESZER, OF CINCINNATI, OHIO.

Claim 2.—In a smoke-consuming device, the shell for the furnace wall, provided on each side with the guide *H*, and having the forward portion of its roof inclined, and the nozzle having the side lugs respectively engaging the adjacent guides *H*, and having in its roof the inclined forward portion engaging said inclined forward portion of the roof of the shell. Seven claims.

913,023. BOILER-CHECK-VALVE CLEAN-OUT. JOHN-R. MARTIN, OF CLARKSVILLE, TENN.

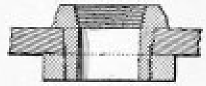
Claim 2.—In a device, the combination of a twin valve casing having two independent inlets and an outlet and inclosing two independent vertically reciprocable valves, a valve-lifting rod for each valve work-



ing through a stuffing box in the casing and having its inner edge adapted to engage and lift the valve when the rod is pushed inwardly, a lever pivoted on the casing and connecting the outer ends of the two rods, a reciprocable operating rod connected to said lever, a blow-out for each valve, and a valve and an operating rod for each blowout. Two claims.

913,265. PIPE CONNECTION. BENJAMIN D. COPPAGE, OF WILMINGTON, DEL., ASSIGNOR TO EDGE MOOR IRON COMPANY, OF EDGEMOOR, A CORPORATION OF DELAWARE.

Claim 1.—An attachment fitting for connecting a pipe into a metallic wall, said wall having a passage through it, comprising a hollow member having a thread for a pipe connection having a body portion extending through said passage and a head secured to said body portion and bearing against one side of said wall, the portion of said head immediately



adjacent the wall being of malleable material to permit it to be calked, and a collar attached to the body portion and bearing snugly against the other side of said wall prior to any calking operation, whereby when the malleable portion of said head is calked, a tight joint between the fitting and the wall is made and the parts are rigidly secured together without injuring said thread. Two claims.

913,277. STEAM SUPERHEATER. ERNEST H. FOSTER, OF NEW YORK, N. Y.

Claim 3.—The combination with a tubular boiler, of a combination chamber at the rear end thereof, a superheater in the chamber, composed of two sections, one located at each side of the chamber, and wing walls extending inwardly from the boiler setting in front of the superheater sections to protect the latter from the direct impingement of the furnace gases. Four claims.

913,442. STEAM GENERATOR. FRED N. TILTON, OF HARTFORD, CONN.

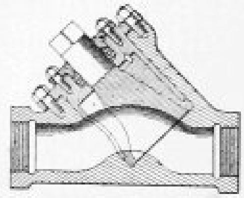
Claim 2.—A generator consisting of a plural number of coils of pipe joined so as to form a continuous chamber from end to end of the pipe, each coil being formed of spirally lying oblong turns, and said coils being of different diameters whereby the smaller is screwed into the larger. Three claims.

913,638. BOILER INSTALLATION. EMILE NICOLAS JOSEPH GERMEAU, OF JUMET, AND ALBERT NICOLAS GHISLAIN BOUTON, OF IXELLES-BRUSSELS, BELGIUM.

Claim 1.—In a steam boiler installation, a boiler, heating chambers surrounding the upper portion of said boiler, movable arches inclosing the upper parts of said chambers, flues adjacent the lower parts of said chambers, openings for admitting heated gases to said chambers from said flues and means whereby the area of said openings may be adjusted. Seven claims.

913,644. BLOW-OFF VALVE. HENRY KIEREN, OF CRYSTAL FALLS, MICH., ASSIGNOR OF ONE-HALF TO FRED H. MILLER, OF CRYSTAL FALLS, MICH.

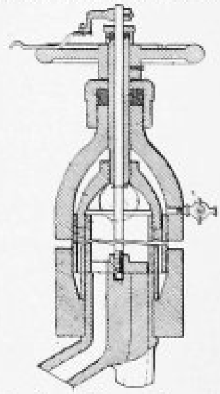
Claim 1.—A blow-off valve for steam boilers, comprising a body formed with a passage extending therethrough, and an annular shoulder encompassing said passage, a plug mounted to turn in the body portion and formed with a passage designed to control the passage through the



body and a renewable seating encircling the plug and resting upon said annular shoulder, and means for holding said seating in place, the seating being formed with a port designed to register with the passage in the plug and being split from the plug to the outer periphery of the seating, and from the port therein to the top or outermost wall thereof. Five claims.

913,675. FLUE CLEANER. EDWARD B. BARNHILL, OF MARION, IND., ASSIGNOR OF ONE-HALF TO MARION MACHINE, FOUNDRY & SUPPLY COMPANY, OF MARION, A CORPORATION.

Claim 6.—A boiler-flue cleaner comprising a casing having a steam inlet, a plurality of rotatable nozzles carried by the casing, and having



inlet ports communicating therewith, and a valve controlling said ports successively. Six claims.

914,940. BOILER-FLUE CLEANER. JAMES J. FLYNN, OF ATLANTA, GA.

Claim 1.—In a boiler-flue cleaner, the combination with a boiler having an opening formed in one end thereof, a tube adapted to be projected through the opening and to engage successively the flues in said boiler, a baffle plate formed with means for permitting a universal movement of said tube, and flexible means connected with a supply of gaseous pressure. Three claims.

THE BOILER MAKER

MAY, 1909

EXPLOSION OF A RENDERING TANK.

BY JAMES H. SPARROW.

At an early hour on the morning of Jan. 11, 1909, a violent explosion occurred by the bursting of a rendering tank at the rendering establishment of the St. Louis Hide & Tallow Company, St. Louis, Mo., which demolished a portion of the building and entailed a property loss of about $22,500. That there was no loss of life or no one injured was due to the fact that the explosion occurred at about 4.30 A. M., and at that hour only three employees were on duty—the night engineer, the watchman and the man having charge of the tanks. Fortunately, these men were in a portion of the building which was only slightly damaged by the concussion. But had it occurred a few hours later, undoubtedly there would have been a serious loss of life, as there were some fifteen or twenty men employed in and about the building daily.

The building was an L-shaped two-story brick structure, the east wing being about 70 feet by 100 feet, and the remaining portion apparently a little larger. The east wing—the wrecked portion—contained eleven 60-inch by 16-foot rendering tanks, two small testing tanks and three horizontal tubular boilers.

The boiler pressure and steam line arrangements to the tanks were as follows: Boiler No. 1, 75 pounds pressure; boiler No. 2, condemned and out of service; boiler No. 3, 45 pounds pressure. A 3-inch steam line, leading from boiler No. 1, equipped with a reducing valve and a 3-inch safety valve and steam gage on the low-pressure side, connected with a 3-inch line from boiler No. 3, also equipped with a 3-inch safety valve. This line then continued on toward the tanks a short distance away, where it was reduced in size to 2 inches, and again changed so that three 1-inch nipples entered each tank near the bottom head. The reducing valve and safety valves were set so that no greater pressure than 45 pounds could pass through the line into the tank.

FIG. 1.—PORTION OF EXPLODED TANK, SHOWING NATURE OF THE RUPTURE.

FIG. 2.—BUILDING WRECKED BY THE EXPLOSION.

The rendering tanks were constructed of two half sheets of ½-inch material, rated at about 50,000 pounds per square inch tensile strength; the longitudinal seams were of the lap-joint design, double riveted, having an efficiency of about 69 percent of the solid plate. The head seams and sections of the bottom (conical) head were single riveted. The upper head was dished convexly in the usual manner.

From this description it is seen that the tanks were well proportioned to sustain safely a load of about 100 pounds, providing, of course, that no defects existed—this based on a factor of safety of 6, which is generally applied on vessels of this type. For one of these tanks to rupture under a pressure of 45 pounds or less and cause such a heavy loss, occasioned a great deal of surprise, but among those who were familiar with the conditions under which the tanks were operated, it was evident that there was something wrong, which was easily explained later on after the debris had been cleared away sufficiently to make an investigation.

It is quite well known among boiler inspectors who have occasion to visit packing houses and rendering establishments, that the life of a rendering tank depends a great deal upon the nature of the product rendered. There are various amounts of acid eliminated from the fatty substances which enter these tanks during the boiling process, and which eventually attack the plates and rivets, in some instances causing rapid deterioration. The percentage of acid often ranges as high as 25 and 30 percent. In such instances frequent renewal of rivets is necessary, and occasionally a section of material is encountered that requires removal or strengthening with a patch. The average life of a rendering tank in service under these conditions is generally from three to five years. It is, therefore, considered essential for owners of such establishments to insure these vessels with some boiler insurance company, after which periodical inspections are made at intervals of from three to six months by an expert in the service of the insurance company. The writer having had several years' experience in this line, and being quite familiar with the effects generally produced on the plates of these vessels, was given the opportunity to go to St. Louis immediately after the explosion, for the purpose of assisting the local inspector assigned to that district to ascertain the cause.

From a photograph taken of the wrecked building, Fig. 2, the extent of the damage can be plainly seen, or, to make it plainer, it took a large force of men several days to clear away the debris sufficiently to remove the ruptured tank. Fig. 1 shows the nature of the rupture. The circular section at the bottom, containing the convex head, was the upper part of the tank. The point of rupture can be quite plainly seen in the large plate, which is almost straightened out. It can be traced along the edge of the lap of the longitudinal seam, and from actual measurements taken the reduction of area is from the original thickness (½ inch) to 1/16 inch. Of course, we do not consider that the plate was actually 1/16 inch thick prior to the explosion, as it was evidently reduced some in stretching just before it parted. However, upon a close examination it was plainly seen that the extent of the deterioration was sufficient to warrant condemnation of the tank long before the explosion occurred.

It is rather unfortunate that the company that carried the risk, and was responsible for the loss, had taken it over from another company about two weeks before the accident occurred, and as is customary when a new risk is written, the local inspector requested that the vessels be prepared for an internal inspection at an early date, but just before the day set for inspection the tank exploded.

The question may be asked: "How could this tank become so thin as stated above if it was subjected to a rigid inspection every three to six months?" The inspector would surely detect the fast depreciating plates and warn the management of the danger. In looking up the records of previous inspections, which were on file at the plant, there was nothing to indicate that the tank was weak; the report of the last internal inspection mentioned some slight defects, but no repairs were necessary, although the tell-tale condition of the tank after the explosion told a different story.

It is thus seen that frequent inspection of the variously designed vessels usually in service in rendering establishments and packing houses throughout the country is of much importance, although it is a fact that there are some who look upon the repairing or renewal of some of these vessels as a waste of money on account of the low pressure carried, and it is very often rather difficult to convince them that immediate action is necessary in order to avert a catastrophe. It often occurs that the business of the establishment is so pressing that the vessels cannot be conveniently spared from service long enough to inspect, thus placing in jeopardy the lives of those who may be in close proximity. In such instances the inspector is often censured by his employers for allowing the inspections to become overdue, and in order to avoid this the temptation prevails to send in a report of some kind, usually based upon information gained from some one in authority about the establishment. This, of course, can be avoided by taking the matter up with higher officials, and if this fails it is then placed in the hands of the higher insurance officials, who will insist on having the vessels properly prepared for inspection or cancel the risk.

IMPURITIES CAUSING SCALE AND CORROSION.*

BY J. C. WILLIAM GRETH.

The chemist has shown the way in which to prevent scale and corrosion in boilers and also how to prevent losses in the industrial arts. His method is to remove from the water the objectionable salts which it contains by changing the soluble salts into insoluble precipitates, which can then be removed by sedimentation and filtration before the water is used. This process is rational in application, the results certain, and the cost in every case is but a small fraction of the advantage gained.

Natural water supplies furnish the water converted into steam; these supplies are rarely, if ever, pure, for water in its descent to the earth as rain absorbs carbonic acid, some air and other impurities. The carbonic acid absorbed enables it to dissolve certain salts of lime and magnesia. Other substances will be dissolved, depending upon the nature of the rocks, soil, vegetation, sewage and industrial waste with which it may come into contact.

Steam generation is a continuous process, fresh feed water being supplied to the boiler as the water evaporated into steam leaves it; this results in a continual concentration in the boiler of the impurities introduced with the feed water, since none but volatile impurities pass out with the steam. The non-volatile impurities collecting in the boiler manifest themselves as suspended matter, scale, corrosion, or by an increased density of the boiler water.

The suspended matter may be carried in with the feed, or may be due to substances forced out of solution as a result of either heat or concentration, or both. Scale formation in the boiler is due to the action of heat, pressure and concentration on the impurities in solution and suspension in the feed water. Corrosion of the boiler is due to the introduction of gases and acids, or their formation from some of the impurities in solution in the feed water, by the reactions resulting from heat, pressure and concentration. The increased density of the boiler water is due to the concentration of the sodium salts and of the scale-forming salts, to the limit of solubility.

Scale is the great bugbear which steam users, as a rule, fear, and make more or less of an effort to combat, and with good reason. Scale is one of the crucial items entering into boiler-operating costs. Scale can nearly always be attributed to the lime and magnesia salts in solution in the water. The character of the scale depends on the acids combined with the lime and magnesia; on the type of boiler in use, and on the rate, temperature and pressure at which the boiler is operated. For instance, the carbonates of lime and magnesia, when present alone, usually form a soft scale. The presence of calcium sulphate sometimes increases its hardness. A calcium-sulphate scale is generally quite hard.

The following are a few of the items which, from an economic standpoint, make it almost imperative to prevent scale formation, or at least to remove it periodically:

First. Reduced evaporation, due to the insulating effect of the scale on the heating surfaces of the boiler.

Second. Cost of labor required for cleaning the boilers and auxiliaries.

Third. Cost of repairs to boilers, necessitated by their being subjected to overheating on account of the heating surfaces being scaled.

Fourth. Loss of efficiency and earning power of improved furnaces and stokers installed to increase evaporation, which correspondingly increases the concentration of impurities, thus forming a greater deposit of scale, and hence a greater reduction in the efficiency and life of the boilers.

Fifth. Cost of tube-cleaning machines, repairs to them, interest and depreciation on money invested, and labor and power required for operating them.

Sixth. Cost of boiler compounds, or any substances introduced into the boiler to prevent the adherence of the scale-forming matter to the shells and tubes.

Seventh. Loss due to the investment in spare boilers to be put into commission when it is necessary to take boilers out of service for cleaning or repairs.

Eighth. Waste of fuel due to heat lost in cooling a boiler for cleaning or repairs, and that required to bring it to steam again.

Ninth. Loss due to reduced efficiency of boiler auxiliaries, especially in the feed-water heaters and economizers, resulting in lower temperatures of feed water, thus materially increasing fuel consumption.

SALTS WHICH ENTER INTO SCALE FORMATION.

Calcium Carbonate—This salt is in solution in natural waters as the bicarbonate. On heating the water, carbonic acid is driven off and the normal carbonate is precipitated to the limit of its solubility, which in distilled water is about two grains per United States gallon, but in waters containing other salts at boiler temperatures and pressures it varies from about one to five grains per United States gallon. This limit of solubility remains almost constant for a particular water under boiler-operating conditions. The precipitation of calcium carbonate by heat is practically complete at about 300 degrees F. The precipitation, however, starts as soon as the temperature of the water is raised and continues until the limit is reached. The precipitation therefore occurs, not instantaneously, but gradually, and with a diminution of precipitate as the limit of solubility is approached. This is true of all scale-forming salts that are precipitated by heat alone.

The amount of calcium carbonate left in solution in the water depends upon the other salts in solution. Heat alone will effect the removal of both the free and the half-bound carbonic acid; therefore, calcium carbonate will be precipitated, and the precipitate may eventually deposit as scale. The formation of scale from precipitated calcium carbonate depends upon the other substances in solution and the conditions under which the boiler is operated. For instance, if the water contains sodium carbonate, the chances are that the calcium carbonate will be precipitated as sludge. If, on the other hand, the water contains calcium sulphate, the cementing action of the calcium sulphate will tend to form a hard scale, the hardness of which will depend upon the amount of calcium sulphate in solution in the water, and the rate, temperature and pressure under which the boiler operates.

Magnesium Carbonate—This substance has the same general characteristics as calcium carbonate, being held in solution as the bicarbonate. The normal magnesium carbonate, however, is more soluble than the normal calcium carbonate. Further, magnesium carbonate is quite easily dissociated as a result of heat, liberating carbonic acid and precipitating magnesium hydrate, which, at all temperatures, is very insoluble, rarely over one-half grain per United States gallon. The

* Abstract of paper read before the American Institute of Chemical Engineers.

analysis of boiler blow-off waters will usually show both magnesium carbonate and magnesium hydrate in solution, while the scale will generally show magnesium hydrate.

Calcium Sulphate—This sulphate is soluble in natural waters to over 100 grains per United States gallon, and under boiler temperatures and pressures to approximately 25 grains per United States gallon, depending upon the other salts in solution. It is quite generally stated that calcium sulphate is insoluble at 300 degrees F.; this may be the case in a solution of calcium sulphate in distilled water, but it is not the case with natural water supplies or those containing other salts in solution. The analyses of hundreds of samples of blow-off waters show calcium sulphate present to the extent of 25 grains, where temperatures far above 300 degrees F. are maintained. The amount held in solution at boiler temperatures depends upon the amount of other substances in solution, and also upon the rate of concentration of those impurities. Calcium sulphate generally gives a hard scale, deposited in layers. This is probably explained as follows:

In the boiler the calcium sulphate concentrates until it forms a supersaturated solution, from which, on agitation of some sort, it quickly deposits a mass of densely interlacing hard crystals of gypsum, until its concentration drops to the point of saturation. Further, concentration in the boiler again forms the supersaturated solution, from which later another crystalization occurs. These repeated periodic crystalizations of white gypsum, separated by the slow, constant and regular deposition of other scale, would give the laminated appearance generally seen in a calcium-sulphate scale.

Magnesium Sulphate—This substance at boiler temperatures is quite soluble, and when present alone is not likely to form scale, but in the presence of calcium carbonate will react with it, forming magnesium carbonate and calcium sulphate. Magnesium sulphate is also objectionable, because it reacts with sodium chloride, forming the very soluble sodium sulphate and magnesium chloride. This reaction is the result of heat and concentration in the boiler.

Calcium Chloride—This lime salt is very soluble at all temperatures, its solubility increasing with the temperature. It is, however, a fact that with the increase of calcium chloride as a result of concentration, a point is reached where the calcium chloride begins to be dissociated, forming calcium hydrate and hydrochloric acid. The calcium hydrate is quite insoluble at boiler temperatures. Analyses of scale and sludge from boilers fed with water containing much calcium chloride show calcium hydrate, and evidences of corrosion, no doubt due to hydrochloric acid, are usually found. The calcium hydrate formed as a result of this reaction may combine with carbonic acid, either introduced with the feed water or that liberated as a result of heat, and form calcium carbonate.

Magnesium Chloride—This chloride has the same general characteristics as calcium chloride, except that it is more easily dissociated, and whenever present, scale and corrosion result. The scale is due to the magnesium hydrate precipitated, and the corrosion to the hydrochloric acid liberated. In waters containing calcium carbonate, the hydrochloric acid thus formed may be neutralized by the calcium carbonate, forming the calcium chloride and liberating carbonic acid.

Calcium and Magnesium Nitrates—These salts have the same general characteristics as the calcium and magnesium chlorides, but the quantities present in most feed waters are usually so small that not much consideration is given to them. However, there are some water supplies in which these salts are present to such an extent as to cause both scale and corrosion.

Silica—The silica in solution in a water usually does not exceed two or three grains per United States gallon, and by itself will not form scale, but it is always found in the scale when present in the feed water. Silica under boiler temperatures may react with sodium chloride, forming a sodium silicate and liberating hydrochloric acid.

Oxides of Iron and Alumina—These are not usually present to any great extent, but by concentration enter into the formation of scale.

Organic Matter—The substances included under this general term play an important part in the formation of scale, and in many cases when present cause the formation of a hard scale, which otherwise might be quite soft. The reverse is also true with some forms of organic matter. Then, again, some organic matter may prevent the formation of scale by increasing the solubility of some of the lime and magnesia salts.

Sodium Salts—These are present in nearly all water supplies and cannot be classed as scale-forming matter, although present to a slight extent in nearly all scale; this is due to their being present in solution in the water, mechanically held by the scale, rather than from being forced out of solution, for long before such saturation is reached, it becomes impossible to operate the boiler.

Corrosion—Corrosion is the most dangerous of the various troubles due to impure feed water, and the one in many cases the most difficult to overcome. It is usually due to the acids intoduced into the boiler in the feed water, or those formed as a result of reactions between various substances in solution, caused by heat and concentration; in some cases it is due to the oxygen of dissolved air. The different acids cause different kinds of corrosion, and it occurs in different parts of the boiler, depending upon the nature of the acid.

GASES AND ACIDS ENTERING BOILER AND CAUSING CORROSION.

Oxygen—Nearly all waters contain more or less oxygen dissolved from the air. The oxygen of the air is more soluble than the nitrogen, and is frequently the cause of pitting and grooving, especially in those parts of the boiler where the temperature is low and its circulation slow, such as, for instance, in the mud drums of those types of boiler in which the mud drum is not in the direct path of circulation. The corrosion by oxygen is the direct formation of the various oxides of iron. It is next to impossible to overcome this form of corrosion, as there is no practical way of removing the dissolved oxygen from the water. The corrosion, however, is of a mild form and does not, except in rare cases, cause much trouble. The cases where trouble from this source is experienced can almost always be charged to the design of the boiler, for if the circulation is as rapid as it should be and all of the boiler water moving, the oxygen will go off with the steam, possibly causing some corrosion at or above the water line, but not generally to an appreciable extent.

Carbonic Acid—This acid, which is mixed with the air to the extent of about 0.04 of 1 percent, is present in all natural water supplies. It is absorbed by the water, in which it is quite soluble, from the air. The corrosion caused by carbonic acid is usually indicated by pitting and grooving, and it is shown not only in the water space of the boiler but also above the water line and in the steam lines. Its corrosive action is much greater when oxygen is present with it.

Hydrochloric Acid—This acid is rarely if ever present in natural waters, but is formed as a result of the decomposition of some of the chlorides, and reactions between such substances as magnesium sulphate and sodium chloride, and attacks surfaces exposed to steam. Hydrochloric acid is volatile, also very soluble; therefore, corrosion is shown both above and below the water line. This acid attacks the iron, forming the unstable iron chloride which, at boiler temperatures, is dissociated; the iron being precipitated as the oxide, or hydrate, and the acid thus liberated combines with more iron from the boiler, and is in turn again set free. In this way the corrosion goes on indefinitely, constantly increasing in its action on account of the continued increase in the acid contents of the water by the acid that is liberated from the impurities in the water being added to the acid formed by the decomposition of the iron chloride. This concentration of the acid does not take place above the water line, but the heat there is sufficient to dissociate the iron chloride. Corrosion from this cause is usually shown by pitting and grooving, rather than over the entire surface.

Sulphuric Acid—When this acid is present in a natural water supply it is due to drainage from coal mines or industrial plants. It is not volatile and its action shows only below the water line. Its action on the iron of the boiler is similar to that of hydrochloric acid, except that it forms the iron sulphate, which in turn is dissociated into sulphuric acid and the iron oxide or hydrate. This iron oxide usually forms a part of the scale, or is present in the water as suspended matter, giving to the water the characteristic red color of iron rust. A feed water containing only a small amount of sulphuric acid will produce active corrosion, resulting in the destruction of the boiler, on account of the continual formation of iron sulphate and its dissociation into sulphuric acid and iron oxide or hydrate. Many water supplies, especially those contaminated with the waste from galvanizing plants, contain iron sulphate, which, under boiler temperatures, is immediately dissociated.

Organic Acids—Under this head are included acids such as tannic and acetic. They are usually the result of contamination from vegetable or organic matter. The corrosion from organic acids is comparatively mild, but occurs to a greater or less extent, and is very similar to that from the other acids. However, the amount of such acids present in most waters is usually so small that little attention need be paid to it.

DENSITY OF WATER IN BOILERS.

The increase in density of the water in the boiler cannot be prevented, for the evaporation of water into steam leaves the sodium salts in solution; and there is no means by which these salts can be removed from the water, either before or after it enters the boiler. By frequent blowing off the concentration of the sodium salts in the water in the boiler can be reduced, but not entirely prevented.

That portion of the scale-forming salts soluble at boiler temperatures and pressures also increases the density of the water, but these salts are constantly concentrating and precipitating, so that after a certain point is reached for uniform pressure and rate of operation, the analysis of boiler water will remain practically the same, with the exception of a variation in the calcium sulphate and an increase in the sodium salts.

Scale and corrosion are closely related, because of the number of salts which, as a result of heat and concentration, either decompose or react, forming salts and liberating acids; the precipitated salts forming scale and the acids causing corrosion.

The analysis of the water is of undoubted value in determing the substances in solution. There is, however, among chemists a wide difference of opinion as to the proper method of making combinations from the determinations of the various substances in solution. Experience enables a chemist to formulate certain rules, and by careful observation during the course of the analysis, to note the salts present in a particular water. But in reporting the nature of the possible scale formed by a certain water, or the corrosion which might result from its use, not only the analysis of the water must be taken into consideration, but the reactions between the various salts in solution; these reactions, however, do not take place to the same extent in all waters. The amount of scale-forming impurity in the feed water rarely if ever bears a direct relation to the substances in solution in the water after concentration in the boiler, but it does to the amount of scale or sludge formed. However, there is a close relation between the amount of sodium salts introduced with the feed water and the amount found in the boiler water after concentration; this ratio indicating approximately the number of concentrations.

It cannot be definitely foretold that in a certain water containing both magnesium sulphate and sodium chloride there will be a reaction between these salts, yet hundreds of blow-off analyses show the results of these reactions, and the boilers show corrosion resulting from the liberated hydrochloric acid.

It therefore means a careful study of the water and the conditions under which the boiler operates, to determine whether scale or corrosion would result from the use of a certain water. It is almost impossible to predetermine the nature of scale from the analysis of the water. The only safe way is to feed water into the boilers, free from those substances which scale and corrode. Such general statements that waters containing only the carbonates of lime and magnesia will form a comparatively soft scale, and that the calcium sulphate will form a hard scale, and further, that it will increase the hardness of the carbonate scale, should be made with caution, for there are hundreds of instances where a hard scale is formed from waters containing only the carbonates of lime and magnesia, and also where the scale is quite soft in the presence of considerable calcium sulphate.

The nature and amount of scale formed in a boiler depend largely on the rate at which the boiler operates. For instance, in some boiler plants operating considerably below their rating, and fed with water containing as high as 30 grains of both carbonate and sulphate scale-forming salts, in a given time comparatively little scale is formed, and that quite soft; while in others, where the water contains only about 10 grains of these same salts, and the boilers are worked above rating for the same time, a considerable deposit of hard, tenacious scale is formed. The type of boiler also has a bearing on the hardness of the scale. The scale in the watertube boiler is generally harder from the same water than that formed in the return-tubular boiler, or in the old two-flue boiler.

SOFTENING AND PURIFYING WATER.

To soften and purify a water properly means, primarily, a properly designed apparatus in which are met the requirements for complete chemical reaction. These may be summed up as follows:

1. An accurate chemical treatment, accomplished by the introduction of the proper reagents in exact quantities to react with the impurities in a definite quantity of water.

2. Thorough mixture of the reagents with the water to insure complete chemical reaction.

3. An accelerated chemical reaction, brought about by a thorough mixture of reagents and water, and by mixing the sludge of previous softening with the new, finely divided precipitate. Heat will hasten the reactions, but is not essential.

4. A complete chemical reaction, brought about by a thorough mixture of the reagents with the water and by having the apparatus large enough to allow sufficient time for all the reactions to take place, and the apparatus so designed that every part of it is effective.

5. A rapid sedimentation, by having the new, finely divided precipitate weighted by the sludge of previous precipitation, to cause it to settle more rapidly and perfectly.

6. A perfect clarification, by allowing time for sedimentation and final clarification by perfect filtration.

The proper softening and purification of water is, in a sense, a delicate operation, notwithstanding the large quantity of water usually handled. It is not merely a matter of lime and soda ash, but the intelligent use of the proper reagents to bring about softening and purification for a particular water supply, with neither an insufficiency of reagents nor too great an excess. A water containing 30 grains per United States gallon of scale-forming matter is harder than the average, yet in precentage this means only 0.05 of 1 percent of scale-forming impurity. Such a water completely softened should not contain more than three grains of scale-forming matter, or in percentage only 0.005 of 1 percent. When these facts are considered, some idea is obtained of the accuracy of the treatment required for completely softening water. Of course, any reduction of the scale-forming salts is an advantage, but the maximum reduction can usually be obtained for very little extra expense with a properly designed apparatus, when such apparatus is given the necessary attention.

If a water supply contains less than 4 grains of lime and magnesia salts, but contains suspended matter, it should be clarified by sedimentation and filtration. If the water contains more than 4 grains of scale-forming salts, it should be softened and purified; that is, the reduction of the soluble impurities (not including the sodium salts, which cannot be removed) to a point where an analysis will show quantities about as follows: Volatile and organic matter, 1 grain; silica, ½ grain; oxides of iron and alumina, trace; calcium carbonate, 2 grains; magnesium hydrate, ½ grain; but no other compounds of lime and magnesia. Suspended matter should never be more than a trace. Such a water will not form scale nor cause corrosion. It will not form scale because the amount of scale-forming salts left in solution is too small, even with concentration, to form anything but a light sludge. This sludge can be kept at a minimum by proper blowing off, and the boiler, no matter how long it is in operation, will, on being opened, have the appearance of having been white-washed; the iron of the boiler can be exposed anywhere by rubbing with the finger or washing out with a good pressure. Corrosion cannot take place, because the water is slightly alkaline and does not contain either corrosive acids or salts, which, by dissociation or reaction, will form corrosive acids.

THE SHEARING RESISTANCE OF MILD STEEL IN PUNCHING.

BY Y. SEKIGUCHI.

In a punch press the resistance on the punch face increases as the punch presses into the plate, but there is a certain point at which the shearing resistance of the metal becomes a maximum.

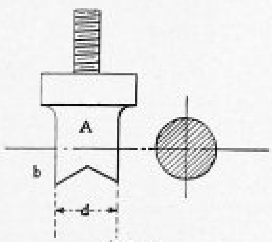


FIG. 1

FIG. 2

PUNCH AND PIECE PUNCHED OUT.

It is of great importance to a designing engineer to know the amount of maximum shearing resistance on the punch as well as the point where the force acts. As a preliminary investigation of the problem, the following tests were made on mild-steel plates:

The punch used in the test is shown in Fig. 1. It has a slight taper to relieve the friction when in contact with the inside of a hole being punched. The diameter of punch was calculated by Unwin's formula,

$$d = 1.2 \sqrt{t},$$

where d = diameter of punch in inches, and t = the thickness of the plate in inches. The tests were carried out in a 50-ton Buckton testing machine, and the load was applied gradually by hand power. Stress-strain curves were traced by the autographic apparatus of the machine.

Fig. 2 shows a shape of chip punched. On examining the surface of the chip, we notice a wave-like line around the circumference of the upper portion. This is due to the action of flow of metal and also partly to a shearing component of compression before the plate begins to be punched.

Fig. 3 is a diagram actually taken from the machine. In the figure, $O\ X$, $O\ Y$, represent, respectively, the shearing stress and the depth of impression in the plate. From O to a

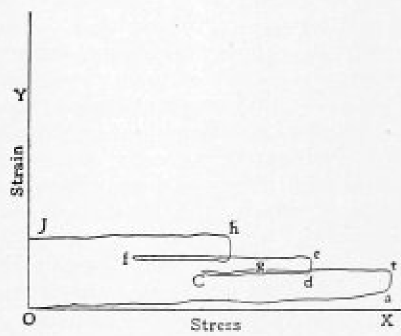


FIG. 3.—STRESS-STRAIN DIAGRAM FOR PUNCHING MILD STEEL.

the load and the resistance increased almost proportionately, but at a the punch suddenly went down into the plate. At t the load was relieved gradually until it balanced with the resistance at C and again increasing the load from C to d the punch presses into the plate as before. By reducing the load e to f, the machine is balanced. Finally, the load is applied from f to h, and the plate punched through its entire thickness.

It is worth while to notice that the diagram shows two lines through C and f. Perhaps this is due to the elasticity of the metal compressed; that is to say, when the load is reduced the metal recovers its shape in a small amount. When the load is applied again the punch will press the chip to the depth along $C\ d$ or $f\ g$, as shown in the diagram.

TABLE I. LOG OF PUNCHING TESTS OF MILD STEEL TO DETERMINE SHEARING RESISTANCE.

1	2	3	4	5	6	7	8	9
No. of Test.	Date.	Thickness of Pate in Inches. (t).	Diameter of Punch in Inches. (d).	Depth of Impression in Inches. (S).	Maximum Resistance in Pounds. (P_1).	Minimum Resistance in Pounds. (P_2).	Mean Resistance in Pounds. $P_3 = \frac{P_1 + P_2}{2}$	Shearing Strength in Pounds per Sq. In. of Metal. $P_4 = \frac{P_1}{\pi\ d\ t}$
1	June 19, 1908	3/8	0.734	3/32	46,590	......	23,295	......
2		3/8	0.734	3/32	38,890	17,760	28,325	......
3		3/8	0.374	3/32	31,700	12,700	22,200	......
4		3/8	0.734	3/32	10,350	1,320	5,835	......
5		3/8	0.734	3/32	10,350	......	5,175	53,900
6	June 11, 1908	1/2	0.848	5/32	70,340	......	35,170	......
7		1/2	0.848	1/8	47,600	25,980	36,790	......
8		1/2	0.848	3/32	29,590	10,710	20,150	......
9		1/2	0.848	1/8	29,590	......	14,795	52,830
10	July 16, 1908	5/8	0.948	5/32	91,730	......	45,865	......
11		5/8	0.948	1/16	84,900	58,020	71,460	......
12		5/8	0.948	5/64	81,980	56,090	69,030	......
13		5/8	0.948	5/64	78,060	52,060	65,060	......
14		5/8	0.948	1/16	71,550	44,690	58,120	......
15		5/8	0.948	3/64	66,770	41,350	54,060	......
16		5/8	0.948	5/64	33,440	11,020	22,230	......
17		5/8	0.948	1/8	33,440	......	16,720	49,420

Table 1 shows the results of the tests.

Fig. 4 is a diagram of curves showing the relation between the shearing resistance and the thickness of the plates. If we write the results in figures we get:

RESULTS PLOTTED IN FIG. 4 SHOWN IN TABULAR FORM.

No. of Plate.	Thickness of Plate in Inches. (t)	Point Where Maximum Resistance Occurs. (t_1)	Ratio of $\frac{t_1}{t}$
1	3/8	3/32	1/4
2	1/2	5/32	5/16
3	5/8	5/32	1/4

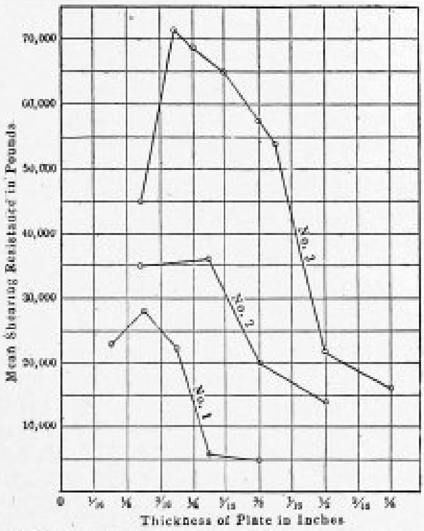


FIG. 4.—RELATION BETWEEN SHEARING RESISTANCE AND PLATE THICKNESS.

The above shows that the maximum shearing stress occurs when the punch has gone through about one-fourth of the total thickness of plate.

Fig. 5 shows the mean shearing resistance at successive

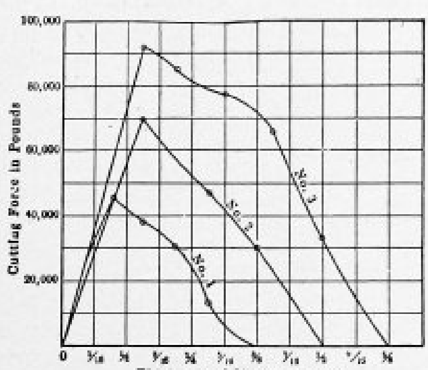


FIG. 5.—RELATION BETWEEN MAIN SHEARING RESISTANCE AND PLATE THICKNESS.

parts of the plate during the punching action. From the diagram we get:

RESULTS PLOTTED IN FIG. 5 SHOWN IN TABULAR FORM.

No. of Plate.	Thickness of Plate in Inches. (t)	Point Where Maximum Resistance Occurs. (k)	Ratio of $\frac{k}{t}$
1	3/8	5/32	0.417
2	1/2	9/32	0.562
3	5/8	5/32	0.250

The maximum mean resistance acts on the punch face when it has proceeded through about 0.4 of the total thickness of the plate.

The tests were repeated by punching a plate at a high speed, and in this case the shearing stress reaches its maximum just

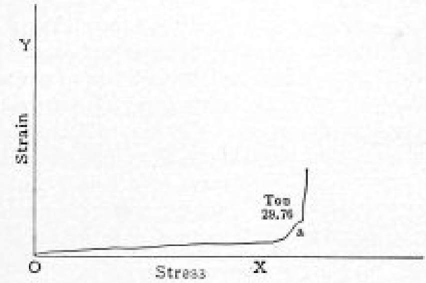


FIG. 6.—STRESS-STRAIN DIAGRAM FOR RAPID PUNCHING.

before the metal punched. This is shown in Fig. 6.—*American Machinist.*

Uniform Boiler Construction Laws.

At the recent convention of the Canadian Manufacturers' Association, Mr. Leonard, of the firm of E. Leonard & Sons, London, one of the leading Canadian engine-building concerns, said, in part, regarding uniform boiler inspection laws:

"The state of our business is this, that we are confronted in several of the Provinces by a local boiler inspection and construction act. The Provinces of British Columbia, Alberta, Saskatchewan, Manitoba and Quebec, and also the city of Montreal, have their own local boiler inspection and construction acts, and it is playing havoc with our trade, and it requires us to keep an additional thickness and quality of goods to suit these different purposes, and we wish to enlist your sympathy to assist us in bringing about a uniform inspection law similar to that which has been inaugurated and successfully carried out in the steamboat act of the Dominion. If we had that act in force throughout the whole Dominion we could send our boilers from the Pacific to the Atlantic, and vice versa, without any interruption; but we cannot send them now without conforming to this and that local requirement, which hinders inter-provincial trade to a large extent. We have now compiled a boiler inspection act of our own, which we will put before the public very shortly, and we would like very much for all the members of this association to assist us in bringing about its adoption. The different States of the Union have been confronted with this problem, and now are trying to solve it, and it is gaining very fast the sympathies of the public. We are confronted with the same thing here, and wish, if possible, to have you co-operate with us by bringing to the attention of your different members in the Local House a notice of this very important question. It is something that the manufacturers should take hold of right away, before any more local acts are passed, in order that we may advance the interests of the whole. The boiler manufacturers want to furnish the very best possible article that can be made; they want the very best material to be put into it, and the very latest modes of constructing that material, and at the very lowest price that is possible for good work."

These remarks of Mr. Leonard were supported by Mr. D. W. Robb, of the Robb Engineering Company, Amherst, N. S. In his opinion it was important to the manufacturer to obtain uniformity of construction, but it was also necessary to users of boilers to get a good, safe, well-made article, which would be subject to uniform inspection. Marine boilers are very well covered, both in England and in Canada, in that respect now, but for stationary boilers on land it is not covered at all, except in some instances by these local acts. The difficulty about these is that while the acts are very good as far as they go, they are not uniform.

"Manufacturers in the States are striving to do exactly what we want to do here—to get a uniform law. Their difficulty is that the lines are so strictly drawn between State rights and Federal rights that it is a very difficult thing to get a Federal law. They think possibly they may do so. I don't think those difficulties stand in the way in Canada. There could be a uniform law for land boilers as well as for marine. At all events there are two or three ways to get at it—through the Federal or local government—but the preference would be to have a uniform law by the Dominion government."

Reducing Grate Area.

The application of a narrow fire-box with but 33 square feet of grate area to a large Pacific type locomotive, having 3,927 square feet of heating surface and weighing 243,200 pounds total, is a decided departure from the usual present-day practice in locomotive design. This has been done on the Chicago & Alton Railroad. This road, in common with most others, was greatly troubled with leaky flues and fire-boxes, particularly in bad-water districts, upon the general introduction of the wide fire-box boiler five or six years ago. Careful study of the problem led first to experiments with wider bridges, and hence fewer flues and less heating surface, which proved successful in reducing flue leakage troubles very materially with no noticeable reduction in boiler capacity. It was next decided that the short life of the fire-box sheets and the excessive leakage was largely caused by the straight side sheets. Experiments with one of the same class of locomotives, fitted with a narrow fire-box, having curved side sheets and wide water legs, proved the accuracy of the conclusion. In two years' service it was found that the cost of maintaining the wide and narrow fire-box boilers on otherwise identical locomotives varied in the ratio of 4 to 1. As a result the next order of twenty-five Atlantic type locomotives were fitted with narrow fire-boxes, and after two years' experience with them the same design is retained on five Pacific type locomotives.

Of course, the reduction of grate area has increased the rate of combustion per square foot, and it has probably also somewhat increased the coal consumption per hour. The recent experiments on the testing plant at Altoona indicate that if the fire-box volume is not reduced the increase in the rate of combustion per square foot of grate area within reasonable limits does not affect the efficiency of the absorption of the heat, although it does affect the efficiency of the combustion. The latter feature, however, depends so largely upon the quality of coal used that no rate can be given which would have general application. As regards the fire-box volume in the present case the narrow grate has reduced it much less than might be expected.—*American Engineer and Railroad Journal.*

Two Compressed Air Rams.

I inclose a sketch, Fig. 1, of an air ram for use in the boiler repair shop. An arrangement similar to this is in use in one of the large railroad locomotive repair shops, and it is claimed that with its use one man does a job (taking out a mud-ring) in one day and a half which often took two men as much as eight days.

The arrangement is plainly shown in the sketch. It consists of a hammer fastened to a piston, which is connected to a smaller piston by a rod. The whole is contained in a piece of lap-welded iron pipe, 5 feet 6 inches in length by 5 inches inside diameter.

It is suspended near the boiler from which the mud-ring is to be removed, a chisel-shaped tool is used to cut the heads from the rivets. Then a punch-shaped tool is used to drive the rivets out. This ram is operated by compressed air, and the blow is automatically continuous.

By referring to the sketch it will be seen that by the use of hand-wheel *A* the length of stroke of the *D*-slide valve will be limited, and thus by throttling the air as it enters the small cylinder the speed of the return stroke will be reduced. This will result in reducing the number of blows delivered per minute.

By adjusting the hand-wheel *B* the speed of the driving stroke and the force of the blow may be reduced or varied.

The *D*-slide valve is operated by a 3-inch air cylinder, which becomes connected to the portion of the cylinder containing air under pressure after the respective piston passes a certain

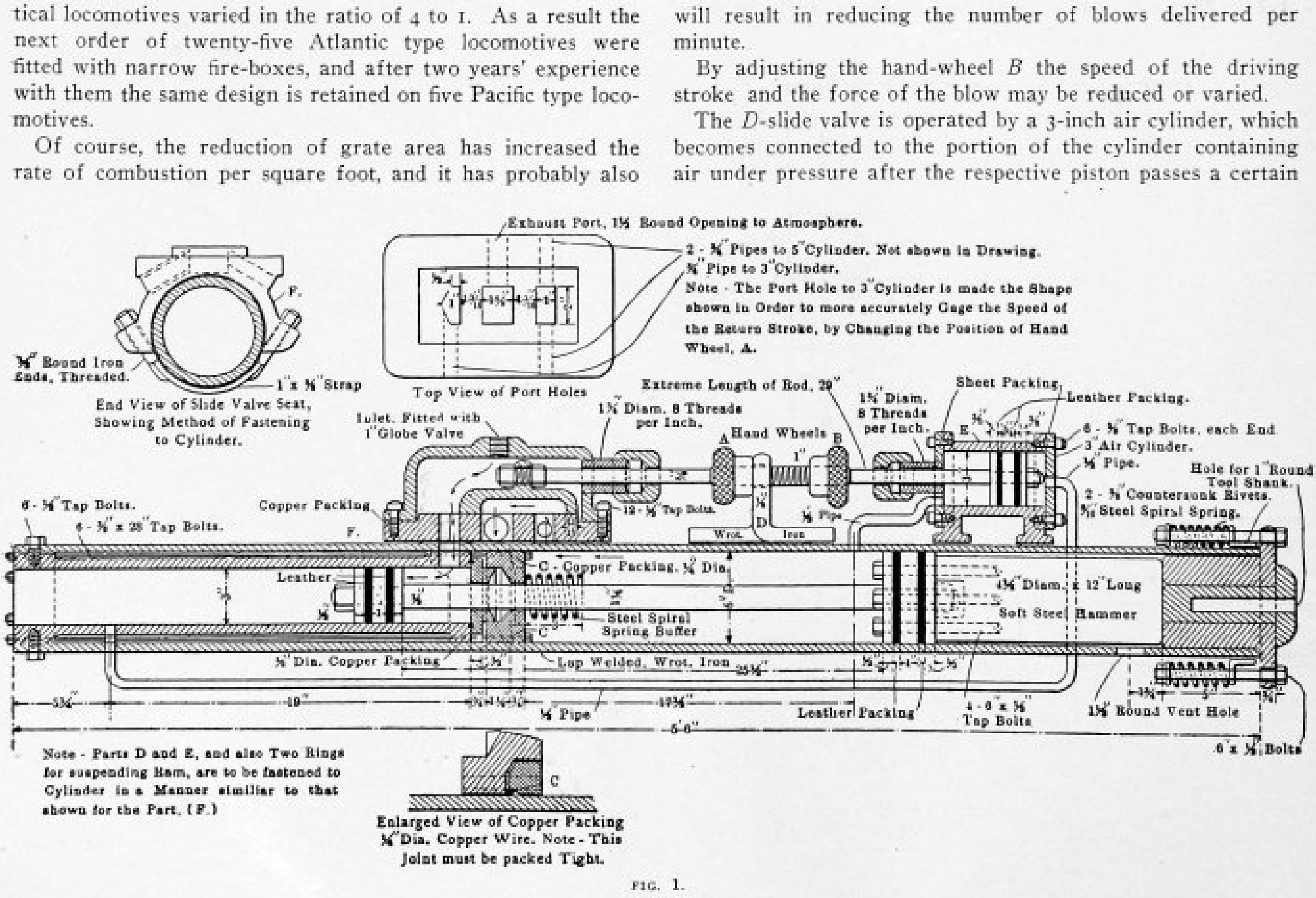


FIG. 1.

point in its stroke. These connections are shown and marked ½-inch pipe.

Fig. 2 is another form of air ram to be used as a substitute for a sledge hammer where there is not room enough to swing a sledge. I have found this arrangement very useful for driving bolts in and out of locomotive frames. As indicated in sketch, the ram is operated by compressed air, controlled by a hand valve.

This little arrangement is not expensive to make, and is very often needed wherever compressed-air connections are available, and especially in repair work.—*W. S. Drummond in the American Machinist.*

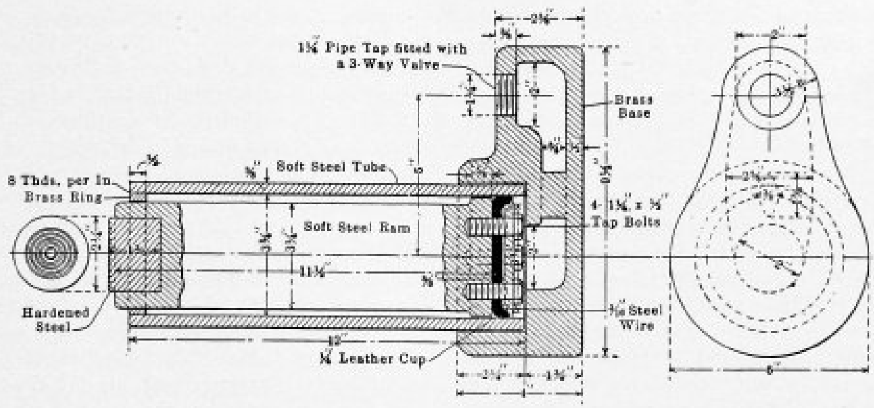


FIG. 2.

PRINCIPLES OF FURNACE DESIGN FOR SMOKELESS COMBUSTION.*

The design of furnaces for the smokeless combustion of fuels, such as oil, anthracite coal and coke, presents no great difficulties, but when we have to deal with the bituminous coals of the Eastern interior coal field, of which the various coal beds of Illinois constitute the greater part, the design of boiler furnaces which may be operated smokelessly involves certain details of construction, the proper arrangement and adjustment of which constitute difficult problems.

It has been held by many people that the burning of bituminous coal without smoke could only be accomplished by a considerable sacrifice of economy and efficiency. This, however, experience and practical tests have proven to be an erroneous idea, quite the reverse being, in fact, the true state of affairs. Mr. A. Bement, who may be considered the pioneer in this field, and who, with Mr. W. L. Abbott, has accomplished more, perhaps, than any other investigator toward the solution of the problem of smokeless combustion, has said: "Experience has proven that, with the exception of the interval at which fires are first lighted, it is entirely feasible in steam making to employ a boiler-furnace apparatus which will be entirely smokeless, so that a photograph taken of its chimney would show no smoke whatever—in fact, would give no indication whether the chimney was in service or not, and in many instances fires are lighted only about once a month. This performance is due entirely to the inherent characteristics of the apparatus itself, and is not dependent in any sense upon the care or skill of the attendant, and the chimneys serving the boiler so fitted have since given evidence of the possibilities in smokeless combustion even when burning coal at the rate of 1 ton per minute."

A furnace designed for smokeless operation with coals of high volatile content, which includes all coal mined within the region mentioned above, must, in effect, be a gas producer and a gas burner combined, and must also be able to take care of the solid fuel remaining upon the grate after the distillation of the volatile matter has taken place. Furthermore, it should be durable and as simple in operation as possible. The fact that a boiler furnace is a piece of apparatus used for the purpose of converting the latent energy of the coal into such form that it may be utilized for the production of steam and power, imposes conditions of capacity and economy. In the effort to secure complete combustion, and thereby smokeless operation, it must be borne in mind that the prime object of the furnace is not smokeless operation, but economical operation, and any scheme which will not give good combined efficiency in boiler and furnace operation does not appeal to the man who is buying the coal. Of course, complete burning of the fuel tends to fulfill both requirements, but if this is accomplished by the admission of a large excess air supply, or excessive radiating surfaces, or in any other manner that tends to dissipate the heat of the gaseous products of combustion before they come in contact with the boiler, the loss of a certain amount of the fuel and a smoky chimney will be a considerably better looking proposition to the man who pays the coal bills.

Certain fundamental principles involving the three variables, temperature, mass and time, may be stated upon which smokeless combustion depends: First, it is necessary that the fuel be raised to the ignition temperature; second, that a sufficient amount of oxygen be present to insure complete combustion, and, third, that the temperature of combustion be maintained until the oxidation of the fuel is complete. To apply these requirements to the furnace it is necessary that enough fuel be burned to maintain a high temperature; that the fuel be fed to the furnace in small quantities and in a uniform manner, and that sufficient air for complete combustion be admitted in such a manner as to provide thorough mixing with the distilled gases.

In their practical application the principles of smokeless furnace design impose the following conditions:

(1) Uniform supply of fuel.

(2) Properly distributed air supply.

(3) Capacity to develop high temperatures.

(4) The retention of the burning gases within the high temperature zone until combustion is complete.

The first of these requirements, uniform supply of fuel, is properly met by many of the patent automatic stokers which are at present being manufactured and placed upon the market, notably by the chain grate. This device consists of an endless chain, passing over sprocket gears at both ends of the grate, and moved forward by a system of ratchets and worm gears, driven by an engine or motor. The coal is fed by means of a hopper at the forward end, which produces a bed of uniform

* A paper by C. H. McClure, Chemical Engineer, Commonwealth-Edison Company, read before the Chicago Section of the American Chemical Society.

thickness. As the grate moves slowly forward the fresh coal is gradually subjected to the heat of the surrounding firebrick walls, causing the volatile portion of the coal to be slowly distilled.

There are other ways of accomplishing the same object, and the above description is only used as an example because of its simplicity.

The second requirement, that of properly distributed air supply, is probably the most difficult of fulfillment. As a rule, the major portion of the air supply is drawn through the fuel bed, with such provisions for auxiliary supply as may be demanded by the apparatus under consideration. The proper distribution of air in many cases is only effectually brought about by suitable arrangements of piers, arches, steam jets or openings in the setting, or combinations of these means. Any provision for air supply must be so designed as to admit excess air, for efficient operation often requires a regulation of air supply to meet the load demands of the boiler and variation in the size and condition of fuel.

The most thorough admixture of the gaseous fuel and air is obtained by the infiltration of the air through the fuel bed. In order to use this source of supply to advantage, some means must be provided for the removal of the accumulating layer of ash. The chain grate, and some other forms of traveling grates, carry the ashes over into the ash pit, thereby furnishing a clean surface for the reception of the fresh fuel. On the other hand, the ordinary hand-fired grate is also a hand-cleaned grate, and can only be depended upon to admit air through the fuel for a limited time after cleaning, which cannot be done at very frequent intervals, and for this reason, and also on account of the relatively large quantities of coal fed, at each firing, resulting in the rapid distillation of much volatile matter, other means of effecting a thorough mixture of the fuel with air must be furnished. With coals which show no great tendency to clinker, the so-called rocking and dumping grates provide a fairly effective means of removing the ash, but unless carefully manipulated a considerable amount of unburned fuel may be thrown into the ash pit. In order to correct the inherent faults of the hand-fired furnace, which is very extensively used in small plants, it becomes necessary to install within the combustion chamber deflecting arches or piers, or a combination of these with steam jets or air inlets in the setting or bridge wall. Care must be exercised to so place these devices that mixing shall take place a sufficient length of time before the gases come in contact with the relatively cold surface of the boiler, to permit of complete combustion, otherwise piers or arches will simply obstruct the passage of the gases and steam jets and openings in the setting will only serve to reduce the temperature of the furnace.

The third condition, capacity to develop high temperatures, is dependent upon the force of draft and the area of grate surface, with due regard to proportioning of the space available for combustion without the introduction of excessive radiating surface.

The fourth requirement, the retention of the burning gases within the high temperature zone until combustion is complete, is the one generally disregarded by the designer and builder of furnaces. It has been the custom to so set furnaces and boilers that the flames from the burning fuel strike against the relatively cold surface of the boiler, a condition which tends to quench the flame and bring about incomplete combustion, resulting in the production of smoke and loss of fuel. It is necessary, to obtain the desired results, to provide some means of isolating the mixture of incandescent gases until the action is completed. On account of the dilution of the oxygen of the air by the presence of the inert nitrogen, and its further depletion during the process of combustion, an appreciable interval of time must elapse in order to allow complete oxidation. This requirement is met by forcing the burning gases to pass through a firebrick chamber, formed by an extension of the walls of the furnace. The time required for the passage of the gases through a properly proportioned chamber of this kind is amply sufficient for the consummation of the combustion process. The walls of the chamber are, at the starting of a fire, of no greater aid than the cold shell or tubes of the boiler, but the firebrick is soon raised to a high temperature. With comparatively low settings, the chamber must be longer than with higher settings, and, if the boiler is set sufficiently high above the grate, good results may often be obtained in a chamber extending but a short distance beyond the rear end of the grate. This latter arrangement is not, however, suitable for hand-fired apparatus. After combustion has taken place the mixture of the highly heated products and the accompanying inert gases should be immediately delivered to the boiler.

As a rule, the design of a furnace must conform to the requirements of a certain boiler or type of boilers, the choice of arrangement being ofttimes further complicated by erroneous principles of design in the boiler, requiring a modification in one way or another of the boiler setting or of the baffling of the boiler itself in order to secure the desired conditions.

In the design of furnaces for new installations, where some freedom of choice may be used in the selection of grate and boiler and the location of the apparatus, the problem is not extremely difficult. In the changing of old installations, however, the conditions are often much complicated. Space is valuable, and frequently sufficient room is not available for the most desirable arrangement. If the situation does not appear to be seriously complex, the engineer in charge, or the fireman, can usually furnish a few arguments designed to prove the utter futility of any solution offered. Many different furnace designs have been proposed and few manufacturers of furnace apparatus will admit that their particular article does not include smokeless operation among its virtues. Steam jet devices have been extensively used, and successfully in many cases, but the cost of operation is an undesirable feature. Suitable provision must be made for air supply, preferably through the fuel bed, with, perhaps, in the case of hand-fired installations, openings in the fire doors or setting to permit the entrance of a further supply of air immediately after firing.

So far, all smokeless furnaces, which have proven both smokeless and economical, have been firebrick enclosed furnaces of some form, which provide for the maintenance of the furnace gases at a sufficiently high temperature, during an interval of time necessary to bring about intimate contact with the proper amount of air, and thus insure complete combustion. There are three forms of this type of furnace which have proven smokeless and efficient in operation: (1) The "Dutch-oven," or extension furnace, in which the grate is set some distance in front of the boiler, the gaseous products of combustion being conducted through a suitably proportioned chamber to the boiler. This form has been applied quite extensively to boilers of the vertical and marine types. (2) The firebrick arch roof of various forms, built within the setting and extending back beyond the bridge wall. This type, set sufficiently high above the grate and operated with reasonable care, has been applied successfully to the ordinary hand-fired return tubular boilers. (3) The tile-roof furnace, formed by covering the lower row of tubes of a horizontal watertube boiler with refractory tile. This form of enclosed firebrick furnace has proven to be most satisfactory, both as a smoke preventer and as an economical heat producer. It may be noted here that any form of hand-fired furnace may be made to smoke by careless or incompetent operation. The average fireman considers his work properly done if he keeps the steam up to pressure, evidently considering the economical operation of the apparatus of no special significance. He will cover the fire-bed with a large amount of coal and retire for a fifteen minutes' smoke or chat with a brother workman. Meanwhile large amounts of volatile gases are being distilled off from the fresh coal, the air supply is reduced to some extent by the thickening of the fuel bed, and the furnace cooled to an appreciable extent by the opening of the fire doors and introduction of the excessive amount of cold fuel, and also by the absorption of heat in the process of distillation. The result is incomplete combustion, loss in volatile hydrocarbon compounds and smoke. For this reason, whenever possible, some automatic form of fuel supply should be utilized by means of which the fuel may be fed slowly and uniformly.

In regard to the cost and mantenance of apparatus designed for smokeless combustion, it is very often true that first cost is in excess of the expenditure demanded by the installation of furnaces of similar design, in which no provision is made for the elimination of smoke. The cost of repairs on a reasonably designed smokeless furnace is not much greater than for the unimproved apparatus. When we take into consideration the fact that smokeless operation is, in itself, a saving of fuel which may amount to as much as 20 percent in extreme cases, and may often amount to 10 percent, it can be readily appreciated that the installation of a properly designed furnace, even at the expense of a considerable initial expenditure, is fully warranted.

The desirability of smokeless operation of boiler furnaces is fully conceded by the general public, and should be so considered by the owners and operators of such apparatus, even though economy of operation alone be taken into account. Without due regard being accorded the demands of operation, both from consideration of smokelessness and economy, the result is apt to be loss of fuel and a smoky chimney. The designer must, therefore, so arrange the details of his apparatus, that it may be capable of furnishing a slowly uniform distillation of the volatile portion of the fuel; that it may furnish a properly distributed air supply, not greatly in excess of the theoretical amount required for combustion; and that it may maintain high temperatures, delivering to the boiler, in the products of combustion, the greatest amount of heat compatible with the durability of the available materials of construction.

The Advantages of the Use of Moderately Superheated Steam in Locomotive Practice.*

BY LAWFORD H. FRY.

With the growing use of superheated steam in locomotive practice a number of studies of the theoretical side of the question have been published. All of these, however, have been devoted to proving the value of very highly superheated steam, and have neglected to consider the economies which can be obtained by the use of a low degree of superheat. Recently, however, experience with the Baldwin superheater in actual service has shown that important advantages can be secured with steam having only from 50 to 100 degrees superheat. It is not proposed to study the theoretical side of the arrangement, which gives such satisfactory results in practice. It will be shown that so far as coal consumption is concerned, a low degree of superheat offers practically the same opportunity for economy as does a very high degree of superheat. The conditions of operation are so much simpler with steam at a moderate temperature than with excessively superheated steam, that if the same economy, or even nearly the same economy, can be secured, the low degree of superheat is indicated as being the more desirable for ordinary conditions of service.

In studying the question it is necessary to take into account the operation of both boiler and engine. First let us consider the production of the steam by the boiler, and as a starting point take an ordinary locomotive boiler, having a ratio of grate area to heating surface of about 1 to 60, and a working pressure of 200 pounds per square inch above the atmosphere. Under normal conditions, with a rate of firing of 100 to 120 pounds of coal per square foot of grate area per hour, the boiler efficiency will be, say, 60 percent, so that with coal of good quality, having a heating value of say 15,000 B. T. U. per pound, the boiler will take up and utilize for the production of the steam 9,000 B. T. U. per pound of coal fired The heat above 60 degrees F. in a pound of saturated steam at 200 pounds boiler pressure is 1,172 B. T. U., and consequently for each pound of coal fired there will be produced $9{,}000 \div 1{,}172 = 7.68$ pounds of steam, the feed water being supplied at a temperature of 60 degrees. The temperature of the saturated steam at the boiler pressure of 200 pounds will be 388 degrees F. The products of combustion will leave the boiler tubes at some 260 degrees above this, say at 650 degrees, and their weight will be about 17.5 pounds per pound of coal actually burned, or say 13.5 pounds per pound of coal fired. At this rate (having a specific heat of 0.24) they carry off $13.5 \times 0.24 \times 650 = 2{,}100$ B. T. U., or 14 percent of the heat in the coal fired.

Now, suppose that without any other change in the boiler the working pressure be reduced to 140 pounds and a superheater is placed in the smoke-box to utilize the heat of the waste gases to heat the steam to 400 degrees F., which is 40 degrees of superheat at the boiler pressure of 140 pounds. The tests made with the Baldwin superheater on the Rock Island Railway show that under these conditions the temperature of the smoke-box gases will be lowered about 100 degrees, so that they will now escape at say 550 degrees, and thus carry off $13.5 \times 0.24 \times 550 = 1{,}780$ B. T. U., or 11.9 percent of the heat in the coal fired. The superheater, by reducing the temperature at which the smoke-box gases escape, has increased the boiler efficiency from 60 to 62.1 percent, and consequently the heat now utilized in the steam production is increased to $.621 \times 15{,}000 = 9{,}315$ B. T. U. per pound of coal fired. Now, each pound of steam at 140 pounds boiler pressure and a temperature of 400 degrees F. has a volume of 3.1 cubic feet, and has a total heat of 1,187 B. T. U. above 60 degrees. Therefore, with feed water at 60 degrees, each pound of coal fired will produce 7.83 pounds of steam, and this steam will have a volume of 24.3 cubic feet.

Now examine the case of the same boiler modified to produce steam at 140 pounds boiler pressure with 290 degrees of superheat. The temperature of this steam will be 650 degrees F., and it is obvious that the gases which heat this steam must leave the tubes at a considerably higher temperature. It seems necessary to count on a smoke-box temperature of at least 800 degrees F., and at this temperature the heat carried off by the gases amounts to $13.5 \times 0.24 \times 800 = 2{,}590$ B. T. U., or 17.3 percent of the heat of the coal fired. As compared with the orginal boiler, the efficiency has been reduced from 60 to 56.7 percent, and the boiler now utilizes in the production of steam only $.567 \times 15{,}000 = 8{,}510$ B. T. U. per pound of coal fired. Now each pound of the highly superheated steam has a total heat of 1,317 B. T. U. above 60 degrees, and has a volume of 4.0 cubic feet, so that each pound of coal fired will produce 6.44 pounds of steam having a volume of 25.8 cubic feet.

The next point for consideration is the work which is done by the steam in its expansion in the cylinder. During the expansion the relation between the pressure and the volume can be represented by an equation of the form

$$p \times V^k = \text{constant},$$

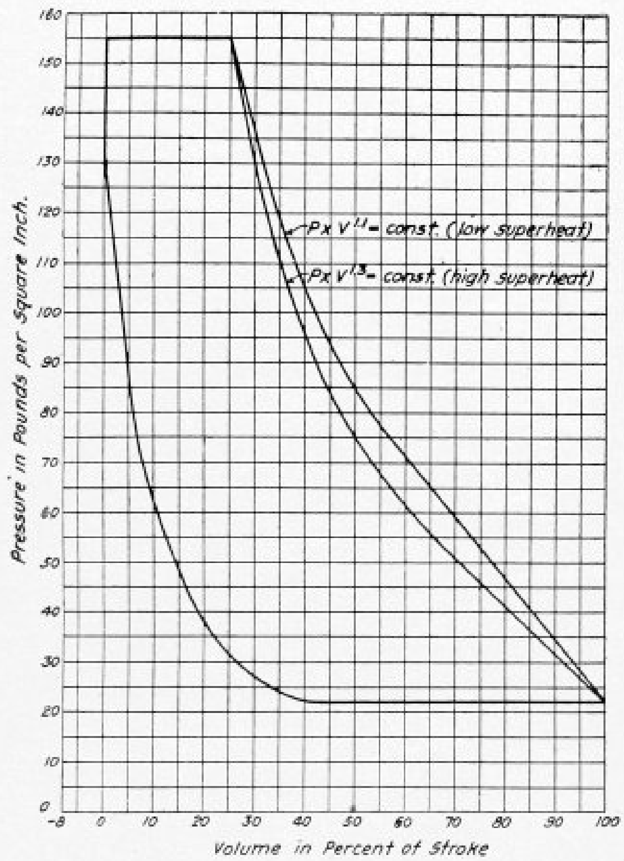
where p is the absolute pressure, V is the volume, and the value of the exponent k is determined by the state of the steam and by the conditions under which the expansion takes

* *Railroad Age Gazette.*

place. The lower the value of k the slower is the decrease in the pressure and the greater is the work developed for a given ratio of expansion. With saturated steam, if the expansion takes place adiabatically, that is to say, without the steam receiving or giving up any heat, the value of k is 1.135. In practice, however, the steam takes up heat from the cylinder walls and from the water produced by the initial condensation, and the pressure being thus maintained above that of adiabatic expansion, the exponent has the value 1.0, and the expansion follows the well-known equation

$$p \times V = \text{constant.}$$

With superheated steam a similar process take splace. The adiabatic expansion of superheated steam would give the value of 1.333 to the exponent k, but in actual practice, though the initial condensation is very much less, yet the steam gives up



COMPARATIVE EXPANSION DIAGRAM FOR SLIGHTLY AND HIGHLY SUPERHEATED STEAM.

some heat on entering the cylinder, and takes a part of this heat again during the expansion. As a consequence, the pressure drops less rapidly, and the value of k is less than in the true adiabatic expansion. Wilhelm Schmidt, whose work in the use of highly superheated steam is well known, gave in the *Railroad Age Gazette* for July 17, 1908, the following values for k:

For a low degree of superheat $k = 1.1$

For a high degree of superheat $k = 1.25$

This means that the highly superheated steam shows a more rapid fall of pressure, and with the same initial pressure and ratio of expansion it develops less work than the steam with the low degree of superheat. We have now to study the application of these formulas to the expansion of the steam, of which the production has already received consideration. The ordinary conditions of operation are fairly represented by the cycle of expansion shown in the accompanying diagram, where the cylinder clearance is 8 percent, cut-off is at 25 percent, exhaust at 60 percent of the stroke, while compression begins at 60 percent of the return stroke. The diagram shows the expansion, under these conditions, of slightly superheated steam with the exponent $k = 1.1$, and of highly superheated steam with the exponent $k = 1.25$ for the expansion line. The saturated steam, which is not shown in the diagram, will expand with the exponent $k = 1.0$. It will be seen that the expansion line of the highly superheated steam lies below that of the slightly superheated steam, and the indicated work is found to be about 2.5 percent less for the same volume of steam. The saturated steam, being at 200 instead of 140 pounds boiler pressure, is not directly comparable on the accompanying diagram, but Mr. Schmidt has shown that at the same pressure and the same ratio of expansion the saturated steam gives about 7 percent higher indicated work than the highly superheated steam.

The diagrams plotted do not take into account the cylinder condensation, which is a matter for separate examination, but show simply the indicated steam. If the diagrams are laid down accurately to scale they can be measured with a planimeter, otherwise one can determine the indicated steam consumption by calculation. It is thus found that in passing through the cycle of expansion shown in the diagrams, from an initial pressure of 140 pounds to a back pressure of 7 pounds, each cubic foot of the low-temperature steam develops 33,980 foot-pounds of indicated work, while the highly superheated steam develops only 33,150 foot-pounds. The saturated steam, with an initial pressure of 200 pounds, in passing through the same cycle of expansion develops 62,100 foot-pounds of indicated work. The three classes of steam differ considerably in density, and if we compare them on the basis of weight we find that the indicated work per pound of steam is 105,000 foot-pounds for the low-temperature steam, 132,300 foot-pounds for the high-temperature steam, and 133,000 foot-pounds for the saturated steam.

Now, to combine the engine and boiler efficiencies. With the low degree of superheat each pound of coal fired produces 24.3 cubic feet of steam, and is thus capable of developing $24.3 \times 33{,}980 = 826{,}000$ foot-pounds of indicated work, while with the highly superheated steam each pound of coal fired produces 25.76 cubic feet of steam capable of developing $25.76 \times 33{,}150 = 853{,}000$ foot-pounds. With the saturated steam each pound of coal fired produces 16.5 cubic feet of steam capable of developing $16.5 \times 62{,}100 = 1{,}025{,}000$ foot-pounds. Since 1 horsepower-hour is equivalent to 1,980,000 foot-pounds, the foregoing figures show that the indicated steam consumption for the three types of engines will be 18.9 pounds for the low temperature, 15.0 pounds for the high temperature, and 14.9 pounds for the saturated steam per horsepower-hour. These are the steam consumptions shown by the indicator, and are exclusive of the losses by cylinder condensation and leakage. In the saturated steam locomotive these losses are known to amount to 30 to 40 percent of the total steam consumption. If we assume, for the present purpose, a loss of 37.5 percent, the steam consumption becomes 23.8 pounds per horsepower-hour, which is exactly the figure found by the Pennsylvania Railroad in its tests at St. Louis for single-expansion locomotives. [See page 704 of the report on the St. Louis tests.]

For locomotives operating with superheated steam the cylinder condensation has not been established directly, but it may be estimated by taking the difference between the actual steam consumption and the indicated steam consumption calculated above. It may be taken that as compared with the saturated steam engine, the low superheat will show a steam economy of 12.5 percent, and the high temperature a steam economy of 30 percent. This assumption, which is favorable to the high temperature steam, gives the following figures for the total steam consumption per horsepower-hour, for the low temperature 20.9 pounds and for the high temperature 16.7 pounds. This agrees with the St. Louis results, which show a measured steam consumption of 16.6 pounds of high-temperature steam per indicated horsepower-hour. On this basis we have for the low-temperature superheat a steam consumption of 20.9 pounds actual and 18.9 pounds indicated, a difference of 9.5 percent for cylinder condensation and leakage, while the highly superheated shows a consumption of 16.7 pounds actual and 15.0 pounds indicated, which is a difference of about 10 percent. The figures thus obtained must be used with discretion, but they indicate that with superheated steam the cylinder condensation is not greatly affected by the degrees of the superheat. As has been said above there are no direct measurements available in this connection, but the conclusion arrived at by the calculation seems to be justified by certain general conditions. It is probable that with saturated steam the greater part of the very large cylinder condensation is brought about by water which is carried into the cylinders with the steam. In locomotive practice the steam furnished to the cylinders usually carries from 1½ to 2 percent of water, and it is extremely likely that the cylinder condensation, instead of being 30 or 40 percent would be cut down to a fraction of this if the steam were perfectly dry on entering the cylinders. If the steam is superheated, even though only slightly, although heat is lost on entering the cylinders, still the strong condensing effect of the water is completely suppressed.

To complete the investigation we have to determine the actual coal consumption, which is found from the foregoing figures to be 3.1 pounds per horsepower-hour for the saturated steam, 2.67 pounds for the low-temperature steam, and 2.60 pounds for the high-temperature steam, which is only 2.6 percent in favor of the high as compared with the low-temperature steam.

The accompanying tables enable the figures determined in the course of the above calculations, together with some other figures of interest, to be compared.

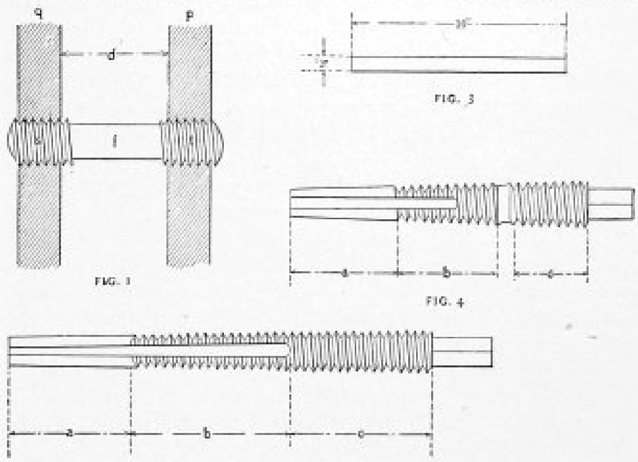
COMPARISON OF SATURATED AND HIGH AND LOW-TEMPERATURE SUPERHEATED STEAM.

State.	Saturated.	Superheated.	
Properties of the Steam:			
Temperature in degrees Fahrenheit	388	400	650
Absolute pressure in lbs. per sq. in.	215	155	155
Degrees of superheat	0	39	289
Volume of 1 lb. in cu. ft.	2.14	3.10	4.00
Weight of 1 cu. ft. in lbs.	0.4675	0.322	0.250
Heat above 32 deg. F., in 1 lb. steam, B. t. u.	1,200	1,215	1,345
Heat required to produce 1 lb. steam from feed water at 60 degrees F.	1,172	1,187	1,317
Indicated work in ft.-lbs. developed by 1 lb. steam expanding in assumed diagram	133,000	106,000	132,300
Indicated work in ft.-lbs. developed by 1 cu. ft. steam expanding in assumed diagram	62,100	33,980	33,150
Properties of the Locomotive.:			
Boiler efficiency in percent	60.0	62.1	56.7
Heat utilized by boiler in production of steam per lb. of coal fired, in B.t.u.	9,000	9,315	8,510
Lbs. steam produced from feed water at 60 degrees F. per lb. of coal fired	7.68	7.83	6.44
Cu. ft. steam produced from feed water at 60 degrees F., per lb. of coal fired	16.5	24.3	25.76
Indicated work in ft.-lbs. per lb. coal fired	1,025,000	826,000	853,000
Indicated consumption (no cylinder condensation) water per h.-p.-hr. in lbs.	14.9	18.9	15.0
Actual consumption with cylinder condensation, water per h.-p.-hr. in lbs.	23.8	20.9	16.7
Do., as percent of sat. steam	100.0	87.5	70.0
Cylinder cond. as percent of steam used	37.5	9.5	9.5
Coal per h.-p.-hr. in lbs.	3.10	2.67	2.60
Do., as percent of sat. steam	100.00	86.0	84.0

Tapping Holes in Two Parallel Plates.

We had to join plates *p* and *q*, Fig. 1, by bolts *f*, the threads *s* and *t* having the same lead. The material of plate *q* was copper, and that of *p* was steel. The threads *s* and *t* had to be in the same line.

At the first attempt we used a long tap, and we tried to tap plates *s* and *t* in one operation. The result was not quite satisfactory. We found out, after some investigation, that the long tap was not accurate. We made several tests and found that the thread changed in the hardening. Fig. 2 shows the tap used, *a* being the leading and reaming part; *b* the cutting part, and *c* a full thread used as a guide in plate *p*, while the thread was cut in *q*. Desiring to get an easy cut, we made the tapping portion of the tool with a long taper, and got very thin chips. The tap worked nicely in the first plate *p*, but when it started to cut the second plate *q* it required considerably more power, and the threads *t* and *s* didn't match up as evenly as we wished. We had difficulty when we undertook to screw in the bolts.



TAPPING TWO PARALLEL PLATES.

The fault was in the long tap, which changed during the hardening process. We made a number of bars, Fig. 3, of the same dimensions, and found that we could never be sure about the changing of the steel; it was sometimes longer, sometimes shorter.

Having found that we could not depend upon the steel in hardening, a new tap was made as follows: Part *b*, Fig. 4, was made shorter than the distance *d* in Fig. 1; *a-b* was hardened, but *c* was left soft. As *b* was short the error due to changing of the material was reduced to a minimum. The guide part *c* was cut after the hardening of *a* and *b*. Between *b* and *c* we left a small groove. With this style of tap the results were fairly good.—*E. Meitner in the American Machinist.*

Hidden Crack in a Butt Strapped Joint.

The triple-riveted butt-strapped joint has been assumed to be a complete remedy for the hidden crack to which the lap joint is liable. The following account of the failure of a butt joint in this manner, from the *Monthly Bulletin* of the Fidelity & Casualty Company, will, therefore, be of exceptional interest. It is the third instance of the kind which has come to our attention:

A recent failure of a horizontal tubular boiler by rupture through the double pitch of rivet line of the longitudinal seam is of more than usual interest. The boiler was 72 inches in diameter and of 7/16-inch shell plate. It was about 16 years old. The inner and outer straps were each ⅜ inch thick. The joint was triple-riveted, the single pitch being 3⅜ inches, the double 6¾ inches, and the rivet holes 15/16 inch. This represents standard practice for this thickness of plate, and the calculated efficiency of the joint is 86 percent of the solid plate, the weakest section of the joint being the net plate in the double pitch or outer row of rivets, at which point the failure occurred.

The boiler had been cut out and thoroughly cleaned, and steam had been raised to 80 pounds preparatory to cutting the boiler in with others, when the engineer noted steam escaping through the brickwork at the rear sheet on top. Removing some of the brickwork disclosed a crack extending for five rivets, a distance of 33¾ inches, the rupture being from 1/16 inch to ⅛ inch. The main valve had not been opened. The engineer quietly pulled the fire and, pumping up, reduced the pressure to zero.

The removal of the straps resulted in finding the plate cracked on the inside from rivet to rivet from the rear-head seam to the circular seam. This condition, of course, had been hidden by the inside strap, and was not revealed until the crack had broken through and leaked. The rivet holes had been punched and the burrs were not removed. There were slight marks in the plate along the double-pitch line, indicating the usual bending action when the sheet entered the cold rolls. The plate at the fracture was full size, and showed no reduction in area, which is significant of segregation of carbon at the end of the sheet.

Multiplying the 80 pounds pressure by the radius gives a pressure of 2,880 pounds per square inch on the shell. This multiplied by 33 inches equals 95,040 pounds on a strip 1 inch wide on each side of the then visible fracture. According to all calculations this condition should have resulted in a terrible explosion, as there was nothing to hold the ruptured sides of the sheet together save the frictional resistance of the rivet heads to the severed plate. It is impossible to determine how long the crack existed under the strap prior to showing through the sheet, but there is no doubt it first started from the inner side and worked outwardly. Had the boiler been made with lap seams unquestionably an explosion would have occurred, as the strength of the inner strap in connection with the frictional value of the rivets on this strap would have been lacking. The accident leads one to believe that a test piece should be cut from each end of each sheet, and subjected to the usual chemical and physical requirements, and that the rivet holes in such seams, if punched, should be reamed out at least one-quarter of an inch, with a view to removing the evil effects of the punch.

The conduct of the engineer in charge was truly admirable. First, there was his carefulness in noting and examining the defect; second, his courage in staying with the boiler (a dynamite bomb with the fuse burning) until the pressure had been carefully removed. Such devotion to duty in the moment of danger stamps the engineer as a hero in the highest degree and reflects great credit on the profession.

The entire sheet was condemned, of course, and in view of the cost of repairs a new boiler was ordered.

HYDRAULIC RIVETING AND FLANGING

Hydraulic riveting, in itself, is a simple proposition and requires no special skill to perform. Judgment must, of course, be used in shackling and hanging the work, particular care being taken that all rivet holes are in line with the rivet dies, so as to insure a straight rivet and easy handling of the work. Care should also be taken in fitting and bolting the work to be riveted, so that there will be no spreading of the end of the straight seams.

As to the proper tonnage necessary for the different sizes of rivets and thickness of plate to insure good, tight work, it is agreed by mechanical men that 100 tons per square inch of section of rivet hole is ample, while anything above 150 tons seems to be dangerous. Under no circumstances should a pressure that causes the edges of plates to scallop be used, as that shows an undue stress on the material and is dangerous in the extreme.

In shops that have three or five-stage riveters, the different tonnage is easy to control, but when a single-stage machine is on hand, it must be equipped with a controlling valve that will regulate the amount of pressure desired.

It is essential that all hydraulic riveters be served by a good crane, high enough to accommodate any piece of work to be riveted; the height, however, is governed by the character of work in the different shops.

A good furnace should be provided for heating rivets, placed within easy reach of the heater and steady man. A lever man, steady man and heater are all the men required for the work. In some shops the heater puts the rivets in the holes, and in others passes them to the steady man, who puts the rivets in the holes; head outside; the steady man then helps to guide and steady the work, while the lever man applies the power.

In hydraulic flanging, two styles of machines are a necessity, namely, the four-column press and the sectional machine, each of which has its own sphere of usefulness. The four-column press is best adapted for shops where duplicate work is made, so that the cost of dies and formers will not be too much; the sectional machine will be found more useful and cheaper to operate where the work is of a greater variety. Therefore, the selection of the machine should be governed by the character of work to be done.

In designing the formers for any head the shrinkage of the plate has to be taken into consideration. A good rule is to add to the female die .008 of the diameter of the finished head for heads up to 60 inches and .01 for larger sizes, and subtract twice the thickness of plate plus 1/16 inch to ¼ inch for upset or clearance, according to the thickness of the plate from the male die. However, no set rule can be given for all classes of work, so the designer must make his own allowances, taking into consideration the kind of work to be done and results of his own experience.

The following is the method of using the dies:

After the sheet has passed through the die on the machine, hold the sheet up to the male die by a clamping die fastened to the middle ram, and after lowering the female die, sledge the sheet up to the male die, taking care to lower clamping die and sheet away from the male die before shrinkage causes it to grip it.

In designing a former for any head, proceed as follows: A round head 57 inches in diameter and ½ inch thick will be taken for this illustration. Use the female die for a base to start from; now, 57 inches by .008 = .456 inch, or about 7/16 inch. The female die, therefore, is to be 57 7/16 inches in diameter when cold. As the head is ½ inch thick, subtract from 57 7/16 inches (twice the thickness of plate), which gives 56 7/16 inches. Now we know the deeper the flange and the lighter the plate, the more we need to take into consideration gather and drag on the male die. "Gather" is supposed to signify in boiler makers' parlance "upset." There are numerous formulas on gather or upset for die work, but no set rule can be given for all classes of work, so the designer must make his own allowances, taking into consideration the kind of work to be done and results of his own experience.

It was found that the male die of our round head should be 56 7/16 inches in diameter. If the depth of the flange was not to be over 3½ inches to 4 inches, we would take 3/16 inch off the male die for gather, and make it 56¼ inches in diameter. Some may think 3/16 inch too much, but the female die sizes the head, and if the male die is small the only effect it would have would be to increase the radius slightly at the root of the flange. To offset this effect, make the radius of the male die less than the drawing, that is, if the radius of the head was to be ¾ inch inside, the radius on male die should be about ½ inch. To get the head off the male die after pressing have three or four holes drilled in the female die, and slip in an inch piece of round iron to catch the edges of the flange. The drawing off of the female die will then pull the finished head off the male die. As the female die cools and shrinks it will release the head.

The foregoing gives the general practice with all dies. For cylinder casings, which should be a fairly smooth job, do not take as much off the male die for gather, but depend on the female die to drag out the gather as it passes over the plate. The taper of the male die should be ⅛ inch from top down to nothing at about 2½ inches, the exact depth depending on the depth of the flange. This enables the casing to be started off the die more easily on the draw off after it is pressed. The section at the dies is about 1½ inches by 10 inches wide both ways. Both male and female dies should be ribbed every 12 inches, and have very few breakages. The clamping die is very essential to obtain good results in holding the plate up to the male die.

The dies described can be used on either machine; but, of course, the sectional machine will be limited somewhat as to size, while the four-column press is only limited by the distance between posts. For very large or irregular work, the sectional machine has the better of it, however, as the dies or formers can be cheaply made, and as the machine's name implies, the flanging can be done in sections by holding the plate down by the clamping ram, and then turning the flange down by the moulding ram, afterwards using the horizontal ram to smooth out the edges, repeating the operation until the work is finished.

In all cases of successful management of the machines, the heating of the plates must be taken into consideration, and proper fires or furnaces provided, as the amount of the finished product is entirely governed by the ability to heat the material and deliver it to the machine.

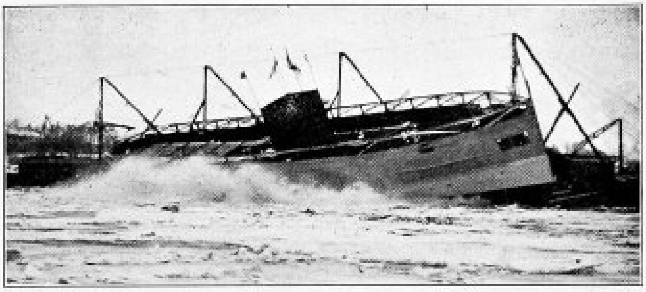
In conclusion, attention is called to the fact that extreme care should be taken of the hydraulic pump, accumulator and all fittings and piping, to see that everything is kept good and tight. This avoids shutting down during working hours for repairs, and at the same time helps to keep the fuel bill where it belongs.—*Ryerson's Monthly Journal.*

BOILERS OF THE UNITED STATES.

BY J. J. FLETCHER.

On Feb. 22 a steel single-screw passenger steamer was launched from the yards of the Manitowoc Dry Dock Company, Manitowoc, Wis., for the Indiana Transportation Company. This vessel, which is named the *United States,* has been designed for an excursion craft capable of accommodating 2,500 persons. She is 215 feet long with a beam of 40 feet and a depth of 17 feet. There are five decks in all, and the hull of the ship is divided into five separate watertight compartments to provide safety in the event of collision.

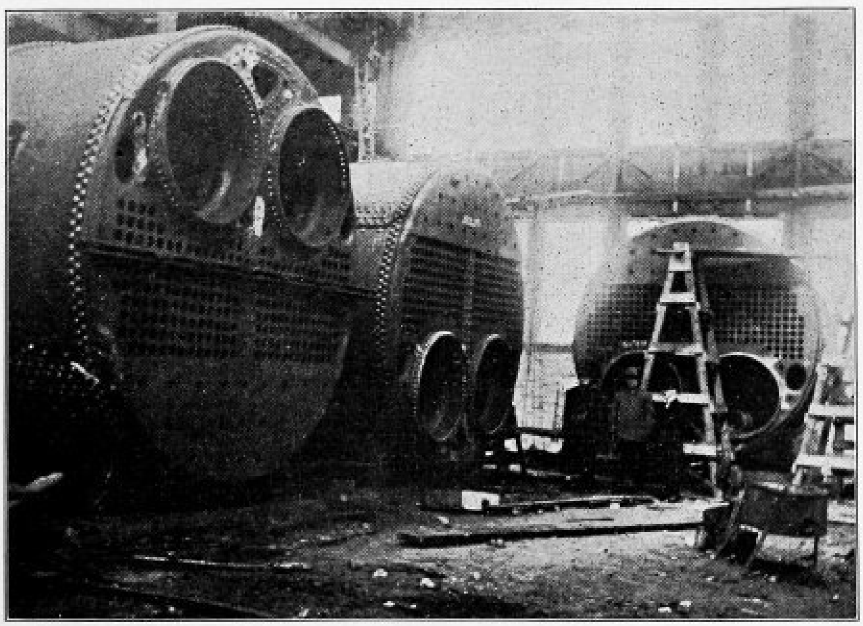
The boat is driven by a triple expansion engine with cylinders 22, 32½ and 60 inches diameter. Steam is furnished at a working pressure of 180 pounds per square inch by three Scotch boilers, each 13 feet 3 inches diameter by 13 feet 7⅜ inches long. Each boiler has two separate combustion chambers and two Morison corrugated furnaces. The furnaces are each 48 inches in diameter and are of the pear-shaped type, so that they can be renewed without disturbing the rest of the boiler. Each boiler contains 236 3½-inch tubes, forty-two of which are stay-tubes. The boilers and uptakes are designed for forced draft.



LAUNCH OF THE EXCURSION STEAMER UNITED STATES.

The boat is being built to comply with the rules of the Great Lake Register, and to make her one of the strongest crafts afloat. The ocean style of marine architecture was adopted; the bulwarks, or sides of the ship being steel, forming part of the cabin and extending up to the promenade deck. Steel deck beams, frames, stanchions, etc., continue up and across the hurricane deck and texas. The hull of the ship is divided into five distinct compartments, by watertight bulkheads, and trimming tanks are installed.

In the arrangement of the passenger accommodations, every convenience has been provided and many unique ideas. Boarding the ship aft, the visitor enters the social hall, which is finished in mahogany. At one end is the lunch counter, and at the opposite end the purser's office, parcel check room, etc.



BOILERS OF THE UNITED STATES.

On the main deck forward is a buffet. Below, on the deck aft, the galley and mess rooms are located, while forward of the engine and boiler rooms are the spaces assigned for freight, crew quarters, etc. Leading up from the cabin to the main deck, aft, as well as forward, are four separate side stairways, a departure from the single center stairway, in order to better facilitate the movement of great numbers quickly and safely.

On the promenade deck are the texas or crew quarters, wireless telegraph and telephone station and passenger staterooms. Aft of the staterooms, on the promenade deck, will be an elevated dance floor, so arranged with a stage as to be available for vaudeville performances. The promenade deck will be covered over and curtains installed along the sides to afford protection in case of windy or rainy weather.

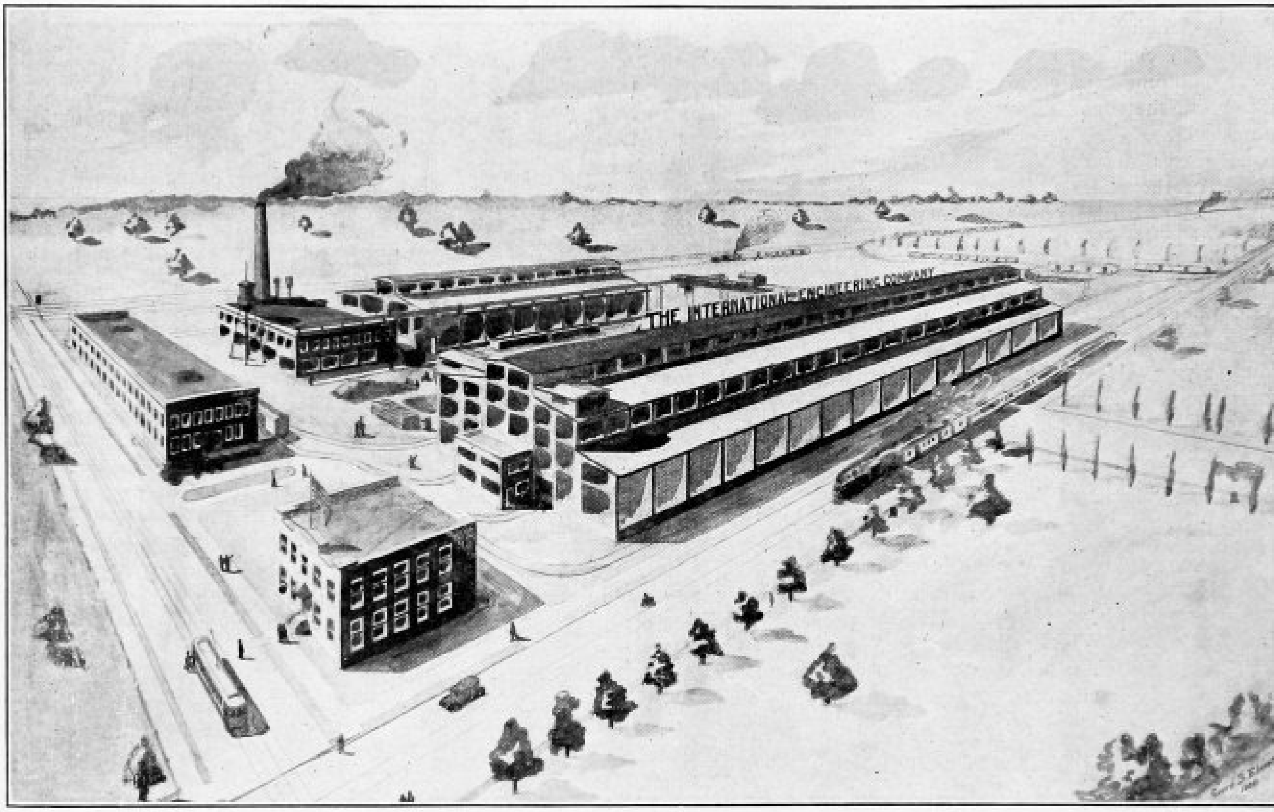


FIG. 1.—GENERAL VIEW OF PROPOSED NEW SHOPS OF THE INTERNATIONAL ENGINEERING COMPANY.

THE DESIGN OF NEW SHOPS.

Year after year new industrial plants are constantly being added. Many of the plants erected, not many years ago, and at that time considered to be the most "up-to-date shops in the country," are now far behind the times. The rapid advances made in all branches of engineering have been the means of vast improvements being made in industrial plants, and these improvements have reduced the cost of manufacture so largely that in many cases an article can now be manufactured for one-half what it cost a few years ago.

In Figs. 2 and 3 are shown the plan and cross-sectional views of the large boiler, engine and light locomotive plant that the International Engineering Company proposes to erect at Erie, Pa. A study of Figs. 2 and 3 will reveal a number of important features that will be of interest to the mechanical world. The wide-awake manufacturer of to-day, when building a new plant, plans for additional growth; and plans to eliminate useless cartage of material from place to place. Many of the older boiler and engine companies of to-day are greatly handicapped, due to the arrangement of their buildings, and when increased business demands additional buildings, the buildings are oft-times located so that the materials must necessarily be transferred from department to department and cannot be transferred with any degree of economy. Nothing tears into profits any quicker than the useless carting of material from place to place—all due to improper arrangement of buildings or equipment, or both. It is an everyday scene in many of the large boiler and engine shops to see a car of boiler plates, tubes, castings, wheels, etc., being unloaded in the same manner as they were fifty years ago. The materials of to-day are naturally larger and heavier than those of a few years ago, and their handling requires facilities other than main strength and awkwardness.

In Fig. 1 the several buildings that are to be erected by the International Engineering Company are shown, together with the 100 percent extensions that are to be added on later. The buildings are arranged so that when the extensions are added the same general plan of handling materials, etc., will continue.

The boiler shop, 60 feet by 200 feet, will have a 20-ton electric traveling crane, running lengthwise of the building. There will also be a 15-ton transverse crane, which will be directly over the hydraulic riveting machines, but it will be unlike the average crane over the hydraulic riveter, for this crane will travel the full width of both the boiler and machine shops a total distance of approximately 120 feet. Referring to the cross-sectional view, it will be seen that the 15-ton transverse crane is elevated above the 20-ton crane—it being possible for the 20-ton crane to run directly under the 15-ton crane. Referring to both the plan and the cross-sectional views, it will be observed that a 20-ton yard crane runs nearly the full length of the property. A feature of the con-

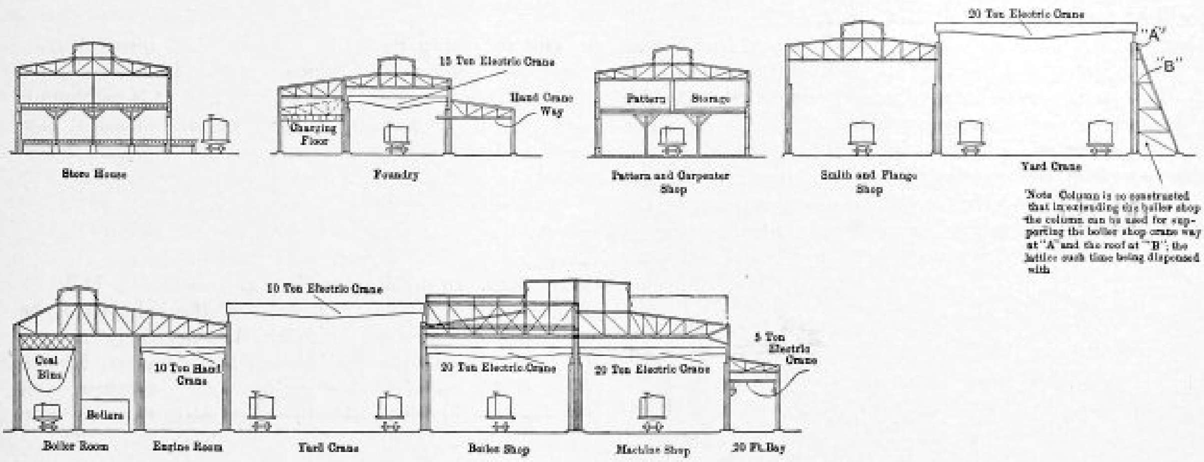


FIG. 2.—CROSS-SECTION OF SHOPS, SHOWING METHOD OF CONSTRUCTION.

struction is, that the uprights for the engine room, boiler shop, the smith and flange shops, in addition to serving their purpose to the respective buildings, likewise serve for the uprights for the yard crane. Referring to the extensions to the boiler, smith and flange shops, it will be seen that prior to the erection of the extensions, the uprights serve merely as uprights for the yard crane. However, when the extensions are added, the lattice work is dispensed with, and the uprights then serve as the uprights for the buildings.

The machinery in the various buildings, as far as practicable, will be electrically driven and so arranged that no power will be used unless the machinery is in commission. Pumps, accumulators, air compressors, etc., will all be located in the engine room. The floor space of the respective shops is to be utilized for the machines and erecting purposes—not for a storage for plates, tubes, castings, engine frames, cylinders, etc. All material in the shop will be material that is needed or about to be needed in the process of some construction. The coal will be stored in coal bins, as indicated in the cross-sectional drawing, and will be conveyed to the bins similar to the process of handling wheat in an elevator. The coal from the bins will be delivered by means of chutes, and the ashes from the ash-pit will, in a similar manner to the coal, be conveyed to bins overhead, so that the ashes can be loaded into a car in a very few minutes.

The boiler, machine, erecting shops, foundry, smith and flange shops, and the power house will be of concrete, steel and brick construction. The office, storehouse, pattern shop and employees' lavatory will be of brick and wood construction, and will be in accordance with the most improved mill construction, complying with the rules of the Associated Factory Mutual Fire Insurance Companies.

The tool room for the boiler, machine and erecting shops is underneath the offices of the superintendent of the boiler department and the superintendent of the machine and erecting departments. The offices of the departments just mentioned are well elevated, and the respective shops in general can be well observed from the offices. The smith and flange shops are consolidated; the flange department being a foreign department to the boiler department, which is a marked departure from the majority of the shops of to-day.

Trackage connections with both the L. S. M. S. R. R. and the N. Y. C. St. L. R. R. are all that can be desired, for, by means of the "loop system," as indicated in the plan view, it will be quite impossible for a blockage of cars to occur. Material to the storehouse can be delivered by two or more tracks to either the side or end platforms. The foundry is arranged so the castings may be delivered directly to the machine shop or platforms, which will be located between the machine shop and foundry.

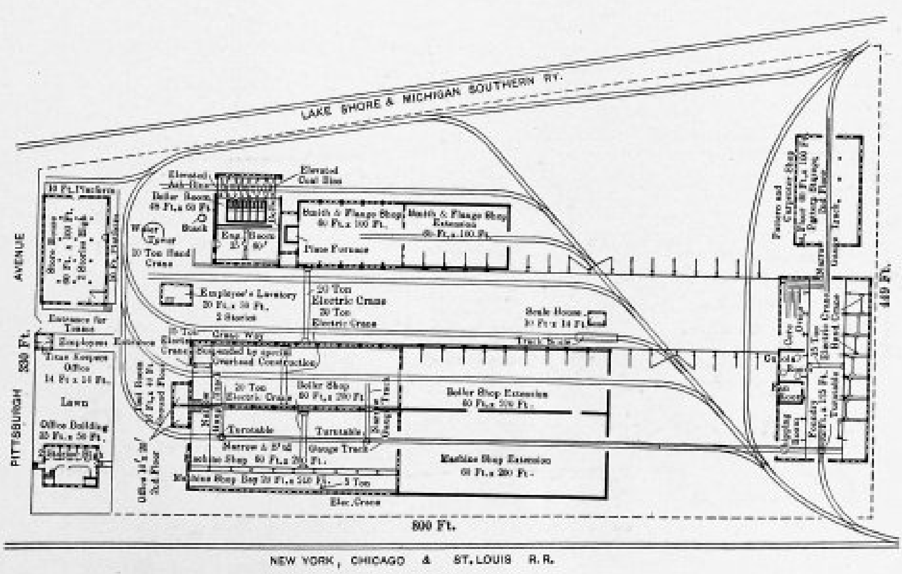


FIG. 3.—PLAN OF SHOPS, SHOWING SHIPPING FACILITIES.

The machine shop, smith and flange shop and the boiler shop will be equipped with portable jib cranes, so constructed that they can be erected on any of the uprights and transferred from one to the other as occasion demands, or, in other words, the crane, when necessity arises, can be taken to the work instead of the work being taken to the crane. The form of jib crane is shown in Fig. 4. There is nothing important regarding the construction of the jib cranes, other than the arrangement which makes it possible to take the crane from one upright to another, each upright being equipped with a bracket. This arrangement has a number of desirable

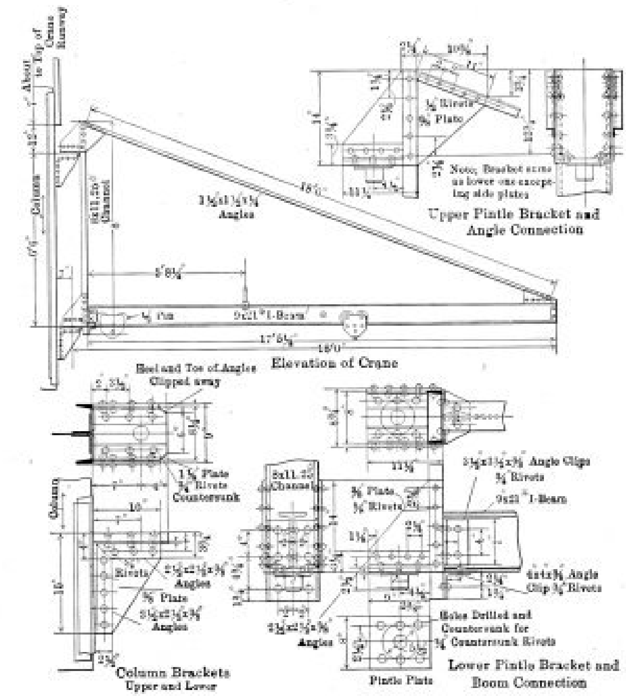


FIG. 4.—PORTABLE JIB CRANE TO BE USED IN THE BOILER SHOP.

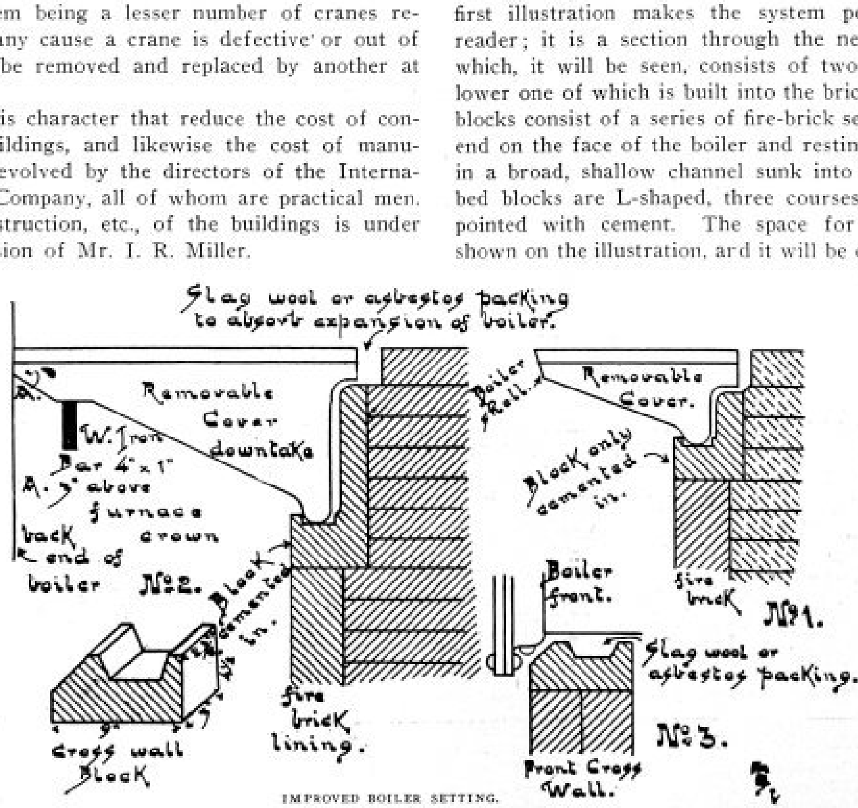
features, among them being a lesser number of cranes required, and if for any cause a crane is defective or out of commission, it can be removed and replaced by another at once.

Many items of this character that reduce the cost of construction of the buildings, and likewise the cost of manufacture, have been evolved by the directors of the International Engineering Company, all of whom are practical men. The designing, construction, etc., of the buildings is under the general supervision of Mr. I. R. Miller.

AN IMPROVED BOILER SETTING.

The following descriptive details and illustrations of an improved boiler setting, which has been introduced into Great Britain, may interest American readers. It is common knowledge among both American and English practical engineers that the efficiency of a steam-raising plant cannot be ascertained with that reliability essential to its importance without facilities for making a thorough investigation into all the conditions of the settings and of other brickwork which support the boiler and constitute an important portion of the outer flues. In the most modern and up-to-date boiler houses, where the firing-up arrangements of the boilers may be considered thoroughly satisfactory and in perfect working order, there may be a very considerable loss of waste heat arising from leaky and defective settings and consequent short-circuiting of gases from side flues and main flues without their yielding up their share of effective heat units. The system which has hitherto been in vogue for the mounting of boilers (of the Lancashire or Cornish types) cannot be considered perfect, as by the ordinary method (to quote an English expert) of mounting boilers the provision made for expansion and contraction is insufficient, inasmuch as the temperature of a boiler changes from one extreme to the other and the strain upon the brickwork therefore becomes so severe that the settings are liable to give way; with the result that cracks appear in the joints and leakages occur.

The advantage claimed for this improved system of boiler setting is, that it is equally applicable for new and existing boilers. By the adoption of the system illustrated in Figs. 1, 2 and 3, the defects in boiler setting mentioned above can be completely obviated without the owners of boilers now in use being put to any very great amount of expense. The system may be described as one of overlapping at the joints, and of providing spaces between specially made and designed fire-clay cover blocks and the brickwork for the insertion of slagwool or asbestos packings, by which means the joints are made pneumatically tight, and yet left sufficiently elastic to allow for the expansion and contraction of the boiler shell. The first illustration makes the system perfectly clear to the reader; it is a section through the new system of seating, which, it will be seen, consists of two series of blocks, the lower one of which is built into the brickwork. The covering blocks consist of a series of fire-brick sections abutting at one end on the face of the boiler and resting on the lower blocks in a broad, shallow channel sunk into them. The lower or bed blocks are L-shaped, three courses deep, bedded in and pointed with cement. The space for packing is distinctly shown on the illustration, and it will be evident that the cover-



IMPROVED BOILER SETTING.

blocks have complete freedom to alter their position to suit the varying conditions of the boiler. The main packing groove also affords facilities to enable sections of the cover to be raised or temporarily removed whenever it is found necessary to examine the boiler and for other purposes. The asbestos packing is, of course, inserted in the spaces shown on the illustrations and can be removed and renewed at will.

The second illustration shows the system applied to the back of the boiler, the cover-blocks are specially shaped for the down-take, considerably deeper and more elongated, and as the front over-hang cannot obtain any support on the boiler itself, it rests on a wrought-iron bar, built in at each end, which is shown in section and may be 4 inches in depth by 1 inch in width. In this case the lower block also is of a different section, six courses deep. When applied to the front cross wall, the system works as shown on the third illustration; special fire-clay blocks are used, with a broad channel for the asbestos packing, 9 inches by 4½ by 3 inches radiated to 2⅜ inches; the front wall is built up clear of the boiler, about a quarter of an inch being allowed for the expansion of the boiler. The slagwool, or asbestos packing, is filled in as the work proceeds. It will be obvious to the practical reader that this system of seating boilers has much to recommend it. When properly carried out it will enable the user to effect a desirable economy in his steam-producing plant while he at the same time provides better facilities for inspection than has been possible under the conditions hitherto existing. Not only is this new system to be recommended in the mounting of new boilers, but it should repay the outlay necessarily incurred in applying it to boilers now at work.

Self-Dumping Ashpans on the Lake Shore and Michigan Southern Railroad.

Two styles of self-dumping ashpans are in use on the Lake Shore & Michigan Southern Railroad, both of which are giving excellent satisfaction. Both of these pans are of the drop-bottom type. Fig. 1 shows the pan applied to a 2-8-0 type of engine, and Fig. 2 shows its application to a 2-6-2 class of engine. It will be noted that the operating mechanisms on these two drawings are somewhat similar in nature, yet they are different, due to the fact that one has only one hopper with two doors, while the other has two separate hoppers. In each case the two doors operate together; that is, when one is opened both are opened, and the same thing is true when they are closed.

These pans have been found successful for several reasons. First, from the fact that warping does not materially affect the tightness of the doors in a closed position; second, any wear in the pins and levers is all taken up by the operating lever; third, the use of a cast-steel frame permits a warped side frame to be straightened and put back into use. Many mechanical men claimed that the cast-steel frame would not pay, but the fact that a warped-steel frame can be straightened makes the cast steel cheaper than the cast iron in the long run. Cast iron frames were tried at first, but it was found that they were constantly warping and cracking; consequently they had to be replaced, as they could not be repaired.

The foregoing are the distinctive features of all the dumping pans used on the Lake Shore & Michigan Southern.

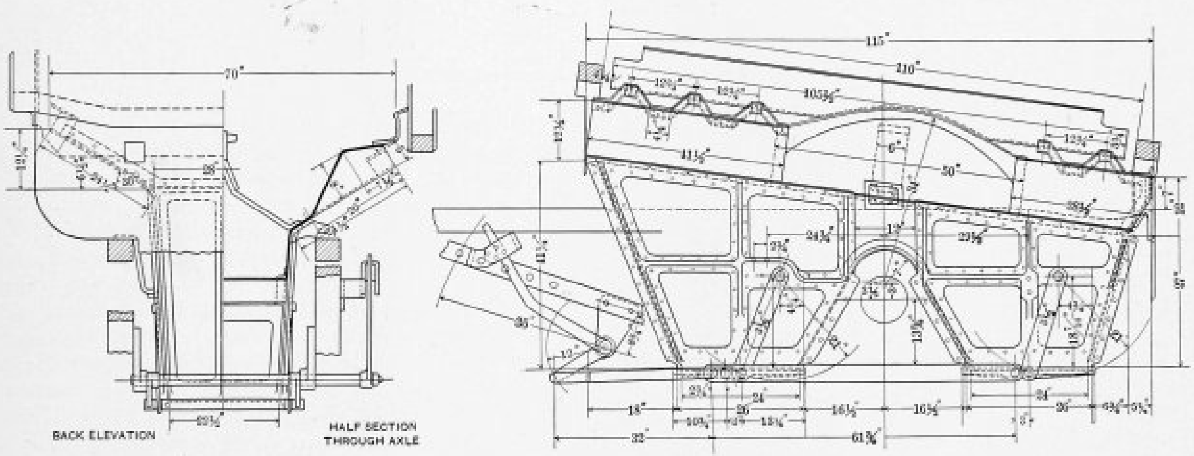


FIG. 1.

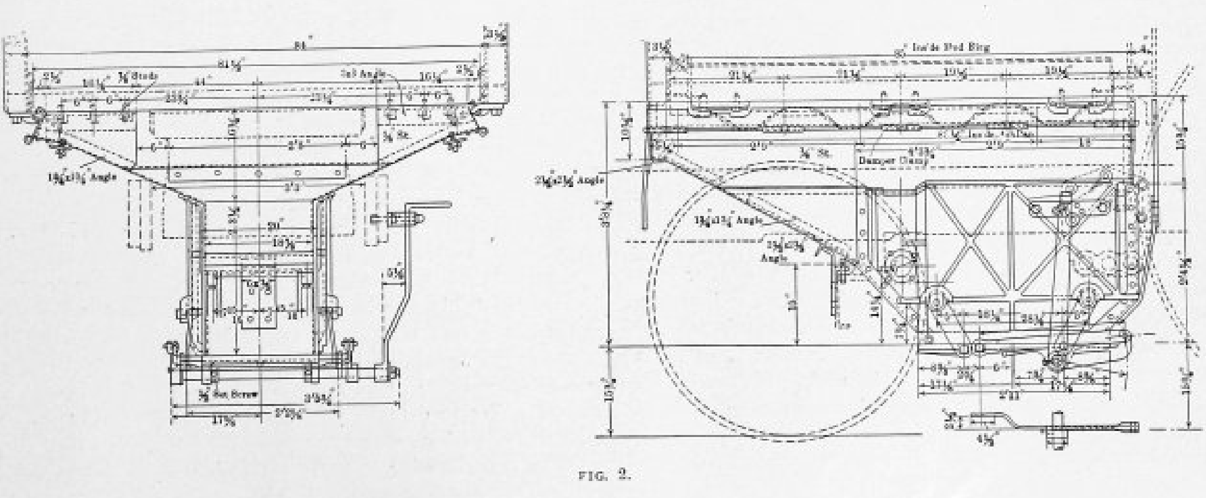
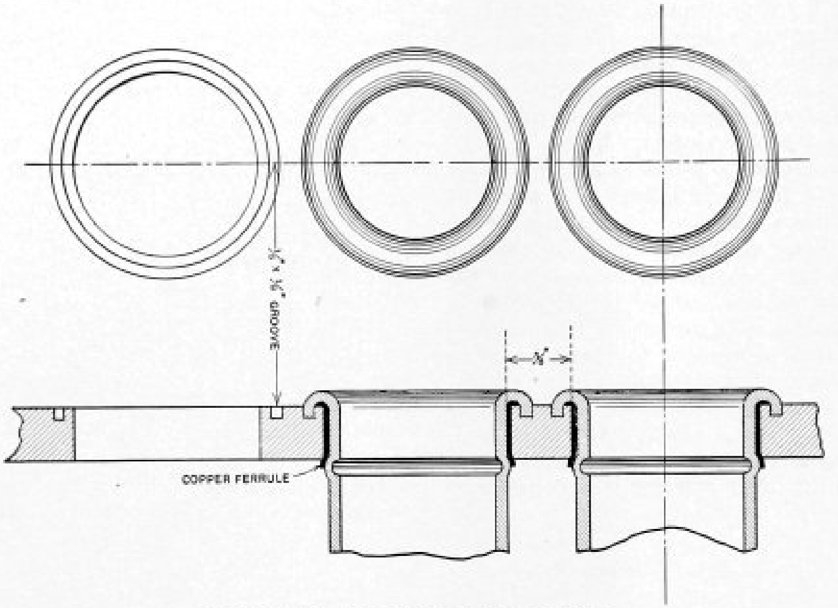


FIG. 2.

A NEW METHOD OF SETTING FLUES.

BY W. P. LUECK.

Many methods of setting flues have been illustrated in The Boiler Maker, but the best method which the writer has seen yet is that devised by Mr. Wharton, foreman boiler maker of the Renovo shops of the Pennsylvania Railroad. Mr. Wharton had a special tool made to fit the flue hole, and on this tool is a cutter that puts a groove in the flue sheet 1/8 inch wide and 3-32 inch deep. The flue is left long enough to bead down in this groove, making one more joint than when the tube is set in the old way. There is no way for the heat to lift the bead out of the groove.



ILLUSTRATING NEW METHOD OF SETTING FLUES.

Before putting in any tubes in this way, a comparative test was made between a tube set according to this new method and one set in the old way. The tube set in the ordinary way pulled the bead through the sheet at a pressure of 8 tons, while the one which was set according to the new method stood 15 tons pressure, and the flue finally broke about 2 inches inside of the flue sheet, leaving the bead uninjured.

In June, 1907, a set of three hundred and sixty-nine 2-inch tubes was put into a large locomotive carrying 205 pounds steam pressure, and up to the present time the tubes have shown no signs of leakage, while the engine has over 98,000 miles to her credit. The drawing clearly shows details of setting flues according to this method.

DRIVING UP BAGS IN STEAM BOILERS.

BY M. KENNETT.

A bag is caused by the sheet becoming overheated from some cause and forced out by the pressure. This overheating is usually caused by an accumulation of scale or sediment on the fire sheet, or it sometimes occurs around the blow-off at the rear. There are two methods of repairing a bag; one is to drive the metal back to its original position, and the other is to cut out the affected portion and put on a patch. Generally speaking, it is a great mistake to patch a boiler on this account unless the bag is unusually deep or very large. A patch is objectionable for several reasons. If it is of considerable size it weakens the shell, unless provided with the same design of riveted seam with which the longitudinal joints are provided, and this is usually impractical unless a half-sheet or two-thirds sheet is put in. Owing to the difficulty of doing the work under unfavorable circumstances, the rivet holes often do not come fair when the patch is to be riveted up, and the drift pin is resorted to, with the result that the rivet holes soon crack out, forming what are known as fire cracks, and causing a great deal of annoyance from the resulting leakage and corrosion of the sheets. Furthermore, it is much more expensive to put on a patch than it is to drive up a bag, even of considerable size.

The process of driving up a bag is so simple that there is little excuse for an engineer calling in a boiler maker to do it, yet frequently bags are allowed to remain in boilers for months at a time because the engineer dislikes to call in the boiler maker. It is not good practice to allow a bag to remain in a boiler, as it forms a pocket which is apt to collect more sediment, and serious results are liable to follow.

To drive up a bag, the plate must be heated to a dull cherry red, and with a short-handled sledge hammer, light enough to be handled easily and quickly, it should be driven back. Care must be exercised to start around the outer edge and gradually work in toward the center, for if the work is started in the center, the plate is certain to be buckled and cannot be straightened without probably removing some of the tubes and driving it back from the inside. When a bag forms in a boiler, the metal is stretched, and, of course, is reduced somewhat in thickness, and in driving it back the metal must be made to flow back to its original position. In order to do this it is plain that the work must be started on the outer edge, gradually proceeding in toward the center as the metal is forced in ahead of the hammer. In the case of a very deep bag it is sometimes impossible to cause the metal to flow back sufficiently to prevent buckling, and in this case it is a good plan to drill about a 1-inch hole in the center of the bag, so that the surplus metal will flow into this space, almost completely closing it by the time the sheet is straightened, after which it should be reamed out and fitted with a rivet.

Do not hurry the heating, and when the desired temperature is reached begin driving up the sheet, working around the outer edge. Work until the metal is almost black, and then heat it again, working in toward the center all the time and taking care not to drive the sheet up too far. It is better, if anything, not to drive it up quite far enough rather than too far, as the finishing may be done with a flatter as a final touch, using a straight edge to make sure there is no depression remaining in the plate. Of course, this cannot all be done in one heat, and if the bag is very deep or large, a great many may be required. In one case a large bag required eighty heats, although not all in one spot.

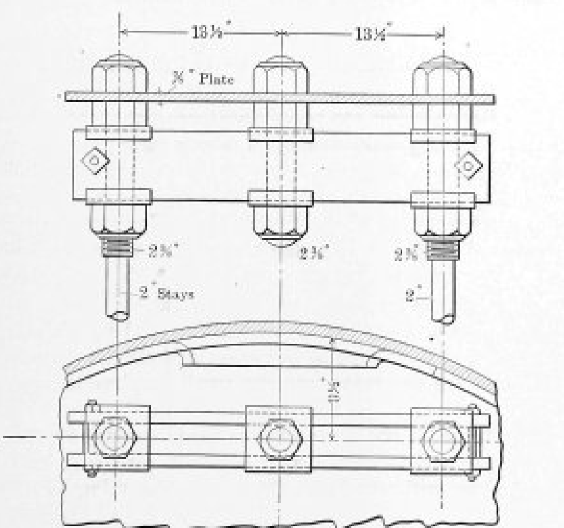
Some engineers are of the opinion that if a sheet has once bagged and been driven back, it is apt to bag again. There is no good reason to suppose that this is the case, however, and the experience of a good many years in this line of work does not justify it. The metal is practically the original thickness, and unless scale or sediment of some kind is allowed to accumulate, there is no reason why the sheet should come down again.

A small amount of oil or grease will produce a serious bag and one difficult to repair, because it extends over a great area, and for this reason, as a rule, cannot be driven back. Furthermore, the patch required is so large that the usual single-riveted seam would seriously weaken the shell, and a joint similar to that in the longitudinal seams must be used. These are not practical where exposed to the fire, and the consequence is that half or two-thirds of a sheet must be put in to bring these joints above the fire line—*Power and the Engineer*.

STAYING THE HEAD OF A SCOTCH BOILER.

BY C. E. SCHAFER.

It frequently happens that a manhole is placed in the shell of a Scotch boiler exactly on the center line of the boiler, so that the manhole comes directly over the center through brace. When located in this position it is difficult for a man to get into the boiler on account of the stay-rod. To obviate this difficulty the writer designed a method of staying the head of a Scotch boiler built for use on one of the Cleveland fireboats and designed for a working pressure of 150 pounds per square inch. This method involved the use of the Schafer



DETAILS OF STAY GIRDER.

patent stay-bar, which gives ample room to pass down through the manhole into the boiler. This stay-bar is absolutely steam-tight, as proper allowance is made for carrying the weight of the bar, and provision is made for expansion and contraction. The same method can be used without the patent stay-bar, and a description of it may be of some benefit to the readers of THE BOILER MAKER.

The illustration shows the method of eliminating the center through brace. A girder made up of two flat bars with clamp washers on both edges of the girder bars, and also two bolts at the ends with separators rests on the inner nuts, which give the girder proper support. The two side rods which have a sufficient sectional area to carry the required load, serve to transmit the stress from the front to the back head, while the short bolt in the center of the girder braces that part of the head between the two side rods.

AN IMPROVED ENGLISH STEAM BOILER.

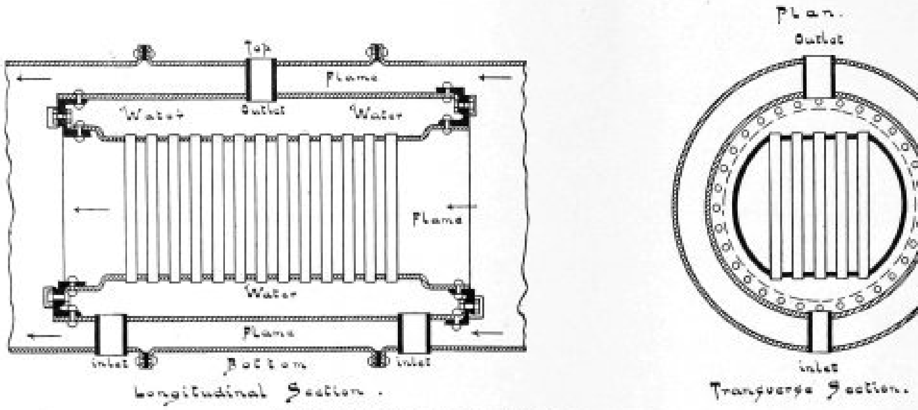
BY AN OCCASIONAL CORRESPONDENT.

It may be stated as a truism both in America and England, where steam is mainly used as the motive power, that the means of its economical generation is of the greatest importance, and any improvement in the means adopted or in the appliances used in attaining that object is eagerly sought after by steam users. The following improvements recently placed on the English market may, therefore, be of interest to readers. English engineers are continually directing their attention to the subject of boiler improvement, and several improvements have been recently made. Recent improvements have been of very diverse sorts, but they all have this in common, that their one aim has been to improve the two recognized types of steam generators, the Lancashire, or two-flued boiler, and the tubular or "Cornish" boiler. The latter, it need scarcely be stated, is a rapid generator of steam, and can be worked at very high pressures with perfect safety, while the former is well suited for mills, workshops and manufacturing establishments generally at which the steam consumption is uniform and steady practically all the year round.

The improvements recently made and described below have been worked out with the object of utilizing the distinctive merits of these two well-known types of boilers, and at the same time to make their working as economical as possible. The illustrations show sections through the interior of a boiler flue as now improved, the sections being one transverse and the other longitudinal. Readers will note from them that the improvements consist mainly of inserting a vertical water-tube boiler into each flue of a boiler of the ordinary Lancashire type, but it should be equally applicable to the Cornish or one-flue type.

The tubes are fixed about 10 feet behind the furnace bridge, consequently the flames from the fire pass round and between them in an almost incandescent state. The series of tubes (on the plan sixty-five are indicated) are fixed in a shell or casing in the manner illustrated, with spaces between them about equal in area to the diameter of each tube. This shell is depressed at the top and bottom to provide a flat surface for the admission of the tubes. In addition to this partially circular tube, there is the outer casing, as illustrated. The annular space between the two shells forms a chamber through which the water circulates. The generator is fed from the bottom of the boiler through the two openings or inlets, as shown, and the heated water is discharged into the steam space of the boiler by means of the outlet above the crown of the flue. By fixing the apparatus in the flue in the position shown in the illustration, the inventor, by great ingenuity, gains in practice the advantages of the water-tube boiler combined with those of the Lancashire boiler, which are retained.

Practical readers will perceive that this apparatus will be most effective as an absorber of heat, as it has been ascertained from careful observation that the temperature of the gases from the furnace in passing through the spaces between the pipes is reduced from 300 to 400 degrees Fahrenheit. It has also been ascertained that in practice the extremely high temperature in which the apparatus is constantly working has the effect of assisting combustion, and by so doing assists in the



SECTIONAL VIEWS OF IMPROVED BOILER FURNACE.

prevention of smoke. The inventor suggests that this is due to the columns of water in the tube having so small a sectional area or diameter that they attain a very high temperature with extreme rapidity, consequently there can be no chilling of the gases. Or put differently, the group of water-tubes produce the effect of a coarse sieve and bring together the unconsumed gases with the free oxygen, thus assisting in obtaining complete combustion. The relatively minute diameter of these water-tubes has the additional effect of preventing the carbon deposit on their outer surface, which occurs in the case of the large tubes used in economizers. This is an important practical point, as it neutralizes what might have been an objection to the introduction of the system.

Practical experience in the working of a boiler constructed on the lines described above has already been obtained, with results as quoted below:

FIRST TEST WITHOUT IMPROVEMENT.

Duration of test	Five hours.
Size of boiler, Lancashire two-flued type	30 by 8 ft.
Diameter of flues	3 ft. 2½ ins.
Heating surface	1,020 sq. ft.
Fire-grate surface	36 sq. ft.
Mean temperature of feed-water	72 degs. F.
Temperature of gases in downtake, taken after the test	1,506 degs. F.
Approximate temperature of gases in the economizer chamber	825 degs. F.
Mean boiler pressure per square inch	100 lbs.
Total weight of fuel consumed during the test	3 tons 5 cwt.
Total amount of water evaporated	4,900 gallons.
A. Total weight of water evaporated per pound of fuel per hour	6.73 pounds.
A. Equivalent evaporation from and at 212 degs. per pound of fuel	7.38 "
A. Total weight of water evaporated per pound of combustible per hour	7.94 "
A. From and at 212 degs. (factor 1.18) per pound of combustible	8.6 "

SECOND TEST WITH IMPROVEMENT INSERTED.

Duration of test with the same boiler	Five hours.
Heating surface	1,020 sq. ft.
Heating surface of improved steam generator	164 "
Heating surface, total	1,184 "
Approximate temperature of gases in downtake	1,167 degs. F.
Approximate temperature of the gases in the economizer chamber	775 "
Mean boiler pressure per square inch	101 pounds.
Total weight of fuel consumed during the test	2 tons 15 cwt.
Total amount of water evaporated	4,900 gallons.
B. Total weight of water evaporated per pound of fuel per hour	7.95 pounds.
B. Equivalent evaporation from and at 212 degs. per pound of coal	8.68 "
B. Total amount of water evaporated per pound of combustible per hour	9.38 "
B. Equivalent evaporation from and at 212 degs. per pound of combustible	10.24 "

(A comparison of the items marked A-A-A with those marked B-B-B will indicate to readers the advantges gained from the improvement.)

The figures given above may be summarized as follows: There is a large increase in the volume of water evaporated, in other words a reduction or saving of over twelve tons of coal per week, which is equal to a money gain of £330 ($1,606) per year; 150 percent on the cost, amounting to a repayment of the outlay every eight months.

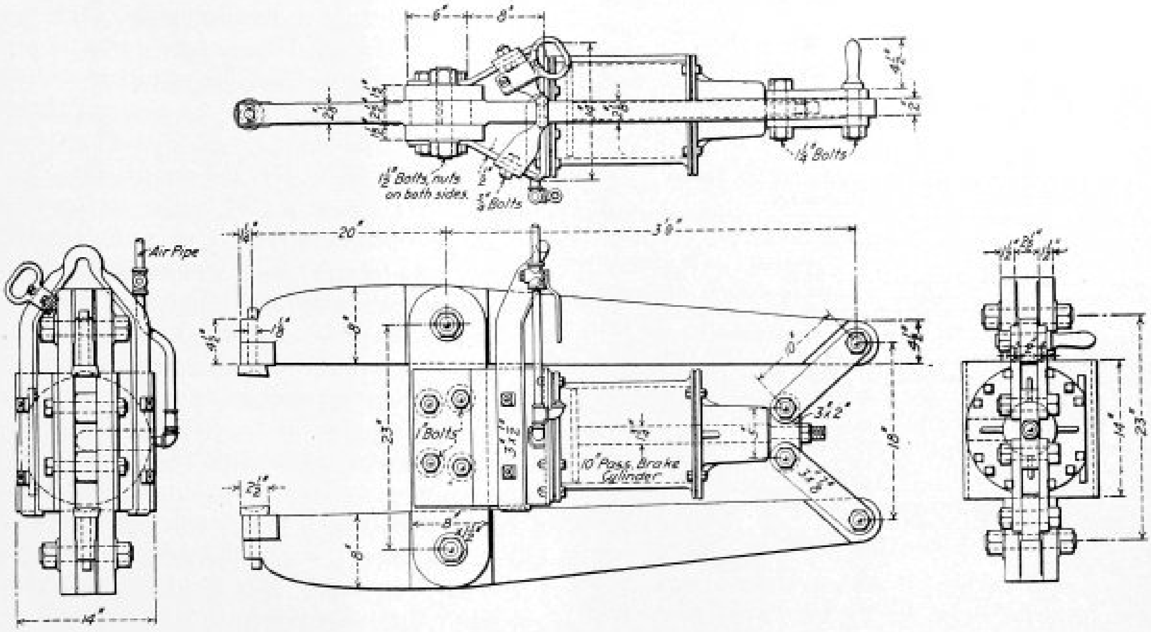
AN EMERGENCY BOILER REPAIR.

A boiler carrying 150 pounds pressure was supplying steam to a small lighting plant through a 6-inch main pipe and a 2-inch auxiliary pipe, which was tapped directly into the boiler for supplying the pumps and some other appliances which required steam independent of the engine pipe. For some cause, either structural weakness or undue strain during repairs, a horizontal elbow just above the boiler, to which was attached by a short nipple the stop valve which cut off steam from the 2-inch pipe in question, split from one end to the other, permitting the 2-inch pipe to fall apart and allowing steam under full pressure to escape into the small monitor located on the boiler house roof just above the boiler.

The cause of the accident was made evident by the falling down into sight of the detached 2-inch pipe with half of the split elbow still attached. Of course, the thing to do was to close, or partially close, the 2-inch pipe, for no 150-horsepower boiler can very long stand the demands of an open 2-inch pipe. The steam pressure began to drop, and realizing that something must be done at once, the engineer called the fireman to his assistance, and they went on the roof of the boiler house, taking with them a sharp-pointed clinker-bar or poker, which was among the fire tools of the boiler, and some rope. The clinker-bar was about 10 feet long, 1¼ inches in diameter at the end, which was tapered down to a point. The 1¼-inch piece was about 4 feet long, and it had been welded to a 1-inch bar, which in turn had been fitted with a ⅞-inch bent-up handle similar to the rake and slice-bar usually found in boiler rooms. A window chanced to be nearly opposite the broken pipe end, and about 8 feet from it. A pane of glass in this window was promptly smashed and the clinker-bar pushed through the opening. After considerable feeling around in the steam cloud, the end of the pipe was finally located, and the engineer and fireman forced the bar into the pipe as far as it would go, and kept it there by lashing the bar to the building.

As the inside diameter of a 2-inch pipe is about 2.06 inches, its internal sectional area will be about 3.3 square inches. The 1¼-inch bar has an area of about 1.2 inches, hence the opening was not much more than one-third closed by putting the clinker-bar into it. This, however, served to hold the steam escape down to a point where the boiler could take care of the drain upon it, and by firing hard and cutting off some unimportant load, the pressure was prevented from falling further and soon came up to normal.

A length of 1½-inch pipe was then procured, and a thread cut on each end of the piece, which was about 12 feet long. A stop valve was fitted to one end of this pipe, and a 1½-inch by 2-inch bushing was provided, but was not put onto the pipe. A 2-inch tee, however, was slipped over the 1½-inch pipe, and a nipple was made into a stop valve and placed where it could be caught up readily. The 1½-inch pipe was taken to the roof, some packing wound around it to protect the hands from the heat, then the clinker-bar was untied and removed from the pipe, and the 1½-inch pipe juggled around and finally pushed into the pipe in place of the bar. The 1½-inch pipe fitted nearly tight inside the 2-inch one, so that after it had been lashed in place and the valve on the end closed, very little steam escaped from the broken pipe, and it was a very easy matter to slide down and place on the 2-inch tee which had been slipped over the 1½-inch pipe. It is probably unnecessary to state that when this pipe was being inserted into the end of the 2-inch pipe the valve on the outer end of the 1½-inch pipe was wide open and the steam allowed to blow through, so as to reduce the pressure against the end of the pipe sufficiently to allow it to be forced into the larger pipe. Once in place, there was put in the tee-branch opening the 2-inch valve with the nipple, described above. Next, the 2-inch valve was opened, then the 1½-inch valve, then the 1½-inch pipe was unlashed and removed, so that the 2-inch pipe was left momentarily open to the atmosphere again. The bushing was then made on the end of the 1½-inch pipe, which was replaced inside the 2-inch pipe—an easy matter with most of the steam escaping through the 2-inch valve. As soon as the 1½-inch pipe had been made in again, both valves were closed and the repair job was done. It only remained to connect the fallen 2-inch pipe with the 2-inch valve which had been nippled into the 2-inch tee. After that, the 1½-inch pipe was removed at the leisure of the engineer, and a plug inserted in the tee in its place. All the operations described above were made within an hour and before the water had become dangerously low in the boiler. This point is not a vital one in these repairs, as the boiler feed was by means of a belted pump driven by the engine, the steam pump and injector being used as auxiliaries.—*James F. Hobart in the Electrical World.*



PNEUMATIC RIVETING MACHINE USED AT THE DETROIT SHOPS OF THE MICHIGAN CENTRAL.

A PNEUMATIC RIVETING MACHINE.

There is in use at the Detroit shops of the Michigan Central Railroad a simple pneumatic riveting machine that is very efficient, which was designed and made on the premises. It consists of two heavy straps, to which are pivoted the two working levers, and between these is the operating cylinder. The method of working is exceedingly simple, and is clearly shown by the engraving. Compressed air, admitted back of the piston, forces out the rod, and by operating the toggles separates the levers at the back and closes them in front.

In order to adapt it to various thicknesses of metal and lengths of rivets, the adjustment is made in the size of the rivet sets, which can be adjusted to take stock varying from 1 inch to 8½ inches. All of the forgings for the machine were made from scrap axles, and the cylinder is an old 10-inch passenger air-brake cylinder. It is used for all classes of work, but principally for riveting truck bolsters and the yokes to draw-bars. It has strength and power sufficient to close rivets up to 1¼ inches diameter, and is used for all the smaller sizes. It will operate and do satisfactory work with an air pressure of from 65 to 70 pounds per square inch, but for the large rivets a pressure of 100 pounds per square inch is to be preferred.

The machine is suspended from a crane by a chain hoist, with which it can be raised or lowered to meet the requirements of the work in hand. Beneath there is a revolving table 16 inches high and 2 feet in diameter, upon which the articles to be riveted can be placed, so that the whole forms a very convenient and efficient machine for the work for which it is adapted and one whose original cost was low.—*Railroad Age Gazette.*

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Vital Points in Boiler Design.

To secure the best results from any given type of steam boiler it is necessary to pay the strictest sort of attention to the design of the furnace. Boiler design itself has settled into fairly standard practice. Thousands of boilers practically alike are now in service, but not all of these give the same results. Years of experience have taught boiler makers how to build a pressure vessel which will provide the greatest amount of heating surface for a given weight and volume, and which, at the same time, is so constructed as to withstand the vigorous usage attendant on the high temperatures and high pressures under which it is operated. Relative proportions of heating surface to grate area, steam space to water space, etc., have become fairly well settled for different rates of combustion and evaporation. The art of constructing steam boilers so that they can safely withstand the hard usage with a minimum amount of repairs is being perfected, but after all is said and done the strongest and safest boiler built may give poor satisfaction if it is provided with an inefficient furnace, so that an excessive amount of coal is required to get the work from the boiler. An inefficient furnace can easily cause losses which, in a very few months, exceed the cost of the entire equipment.

Two distinct and separate processes are carried out in a steam generating plant. First, the combustion of the coal; and, second, the evaporation of the water into steam. There are unlimited opportunities for losses in both of these operations, and, unfortunately, things which tend toward economy in the one direction are frequently the very things which cause inefficiency in the other. For instance, in order to burn bituminous coal it is necessary to first distil the gases from the coal, then mix them with the required amount of oxygen and maintain a proper temperature for their combustion. For this reason it is an advantage to keep the gases at a high temperature in the fire-box as long as possible. On the other hand, the evaporation of the water requires that the heat thus generated shall be extracted from the gas in the shortest possible time. To insure an efficient steam generating plant some compromises must be made between these conflicting elements.

Little is actually known regarding the rate of transmission of heat from hot gases through metallic plates and tubes to water. It is well known that rapid circulation of the water in the boiler and of the gases through the boiler tend to increase the rate of evaporation. This has been proved many times by the simple experiment of stopping up half of the tubes in a locomotive boiler and maintaining the same rate of combustion on the grates. Obviously, the gases must pass through the tubes with twice the velocity, and the corresponding rate of evaporation per square foot of heating surface is doubled. This is accomplished without any great decrease in the efficiency of the furnace. In a recent installation two furnaces were installed underneath the same boiler; one at the front and one at the back. The evaporative power of the boiler was nearly doubled, with a loss in efficiency of only about 3 percent. This, of course, tends to show that with properly designed furnaces, boilers of the same weight and dimensions as are now used should be made to evaporate a great deal more water than they are now forced to do. Increased velocity of the hot gases can only be obtained by increasing the draft. This in most cases is an exceedingly expensive operation, and it is always a question whether it is worth while or not. Increasing the circulation of the water in the boiler is necessary, not alone from the fact that such an increase aids in the evaporation, but also because it equalizes the temperature in different parts of the boiler, so that the expansion and contraction of various parts will be more nearly uniform and reduce boiler failures.

Standardization.

As a whole, steam boiler practice has become fairly uniform, while various details which immediately affect the shop work in the construction of boilers have not been standardized with anything like the care which they might be. Manufacturers of certain kinds of machinery would think it strange if it was necessary to lay out and construct each machine of the same size and capacity which they make with slight changes in the arrangement of bolts and small details, yet the same manufacturer, when building several steam boilers at different times, of practically the same size and capacity, will go through the entire operation of laying out individually each boiler with little regard as to how the work was done previously, the result being that the several boilers may have different types of riveted seams, the pitch and number of rivets may be different, the heads may not be exactly the same size, and, consequently, the shell plates may have been shortened or lengthened accordingly. Manholes and handholes may have been laid out from different patterns according to the ideas of the particular layer-out who had the job in hand, and the exact arrangement of braces and stays may have been slightly altered as occasion demanded. Since this is a method of manufacture actually pursued by many boiler makers, it is evident that there is room for the practice of considerable economy in both time and labor.

Of course, the one factor which has done the most to retard standardization in boiler construction is the lack of uniform rules. Where boilers must be constructed according to different rules and regulations when they are to be installed in different States, it is impossible to secure much uniformity of construction in the shop. The first and most important step towards standardization, therefore, is the establishing of recognized rules for the design and construction of stationary boilers. Once uniform rules are established and recognized, manufacturers can begin to work up standard designs showing the layout of different sizes of boilers in detail, so that the layer-out can keep on file a number of blue prints covering all sizes of boilers, and when an order comes in all calculations for the boiler are at hand ready to be used. The layer-out has each sheet and bar laid out to a small scale in the blue print, just exactly as he must lay it out on the steel. It then becomes a quick and simple operation to lay out the boiler itself, and, whenever repairs are needed to any part of the boiler, new sheets and bars can be laid out in the shop by referring to the drawings, and the workman can be assured that all rivet holes and various connections will fit after the damaged parts have been removed. The advantage of standard designs in the matter of repairs on locomotives is perhaps greater than on any other type of boiler. It should be possible to construct a new fire-box for any one of a certain class of engines while the engine is out on the road, and have it all ready to put in place with all holes punched when the engine comes to the shop, without the necessity of lifting the holes from the old sheets in the boiler and laying off every brace and stay-bolt from the old sheets.

COMMUNICATION.

Standard Punches, Dies and Couplings.

Editor The Boiler Maker:

In a recent article under this title in your magazine (page 46, February, 1909,) certain conditions regarding the use of punches and punch fittings familiar to all large users of punching machinery are discussed and certain deductions drawn as to what should and what should not be embodied in the standardization of these tools. It is with the deductions that we are particularly interested.

In order to arrive at the merits of the case, perhaps it would be well to get under the surface and start at the beginning. The style of punch in common use the world over was invented by Isaac P. Richards, of Providence, R. I., and a United States patent was granted to him under date of June 28, 1870, reissued Jan. 3, 1871. Mr. Richards was a practical maker and user of punches, and, owing to the excessive breakage and attendant expense in the use of these tools, conceived the idea of making the punch separable from the holding stock and attaching it thereto by means of a screw coupling. This invention was soon recognized as eminently practical, and, after the granting of the patent, Mr. Richards took up the manufacture of these goods and has continued to prosecute the business up to the present time, covering a period of about thirty-eight years.

At first his attention was devoted to the making of punches for nut manufacturers. During this time he made and sold a standard punch for riveted work, which was later discarded for the present U. S. standard punch. This change in the standard was not a change in essential features, but simply one of proportions, and was necessitated by the greater severity of the work, due to the increased thickness of the material punched. The head and body of the punch were enlarged in order to more thoroughly brace and stiffen the shank. This change embodies the only material improvement that has been made in punches within the past thirty-eight years.

Since the expiration of Mr. Richards' patent the field has been open to all comers, and during the past few years various concerns have taken up the manufacture and sale of punches and dies and have adopted his standards. Generally speaking, however, there are just two styles of punches used in the United States—the one style following Mr. Richards' earlier model, and the other his later model, the U. S. Standard. In this connection, a glance at the blue-print of the International Master Boiler Makers' Association, recently issued to the manufacturers of punches, is illuminating and will verify the above statement.

During the past year a committee of practical boiler makers have collected data to present to their association at its coming convention, in the effort to arrive at a common standard for punches, dies and couplings. With the purpose of this committee we are entirely in sympathy, because we believe that there should be a single standard for these tools, and that from the standpoint of the user the complication, inconvenience and expense incident to the presence of several different standards should be eliminated. This brings us to a consideration in the use of punches as to what is best from the standpoint of correct mechanics,, efficiency, convenience and economy.

In our opinion, the best punch is a short, stiff, well-braced punch, applied directly to the machine stem and held to it by a screw coupling. "Filling blocks" or "sleeves" are out of place for several reasons. A filling block introduces an unnecessary joint between the stem and punch. It applies the power at a greater distance from the work than when the punch is held directly to the stem. It increases the liability of dirt between the surfaces and so tends to poorer alinement. It does not permit the use of a coupling as strong as is possible without it. Last, but not least, it is a contrivance out of place in a rough boiler or structural shop, and for that reason is a source of inconvenience and loss of time to the operator.

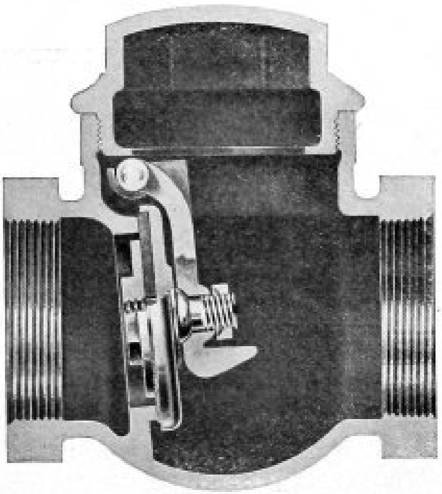
The argument advanced in favor of filling blocks and sleeves is that, with their use, fewer machine stocks are required. In order to save a simple, inexpensive machine stock a sleeve is introduced, which, in additon to some of the criticisms applicable to filling blocks, makes necessary the use of a long, slender punch. The duty required of a punch is too severe to admit of any theorizing which does not square with correct mechanics. A punch of ¾-inch diameter of head, 9/16-inch diameter of body, 2⅛ inches long, will not stand up under as much hard duty as a punch of the same head and body dimensions 1½ inches long. And when it is possible, under severe treatment, to pull the head of a punch entirely through a coupling, obliterating the head bevel in the coupling, it is not difficult to conclude that a little light sleeve, under the abusive treatment common in the use of these tools, will neither retain its accuracy nor contribute to the stiffness and correct alinement of the punch. The punching of long plates and angle-iron brings severe lateral strain upon the punch, and the introduction of any unnecessary parts between the stem and the punch is, in our opinion, mechanically wrong.

Providence, R. I. Prescott H. Coleman.

ENGINEERING SPECIALTIES.

The Nelson Bronze Swing Check Valve.

The valve illustrated is designed for working pressures up to 125 pounds per square inch, each valve being tested to 250 pounds. For steam service this valve has a bronze disc fastened to a self-hinging clapper. When used for hydraulic work, the valve has a leather disc, kept in place by means of a bronze disc retainer. The body is cast in one piece and



the bearing for the clapper is cast in the valve body. The ball and socket joint between the disc and the clapper provides free movement, so that the back pressure causes the valve to seat perfectly. When the valve is open the flow is unrestricted to the full capacity of the line. The valves are manufactured by the Nelson Valve Company, Wyndmoor, Philadelphia, Pa., in sizes suitable for use on pipes ranging from 3/8 to 3 inches in diameter.

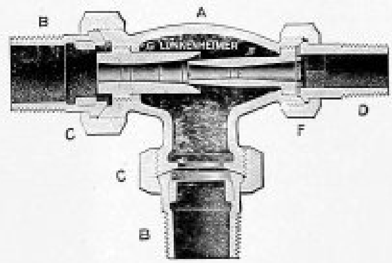
Repairing Car Plates in Position.

The rapidity with which the steel car is supplanting the old wooden type has been due in considerable degree to the opportunity afforded by the former for the making of repairs with greater ease and economy. A large part of the work consists merely in straightening out bent and battered plates, and can be done in place, without the additional cost of removing the injured section; for such purposes as this portable tools have been particularly designed and have found wide favor. The Hauck oil burner, being entirely portable and self-contained, so that it can be used in any position, has been brought out especially for use in building and repairing steel cars, repairing engine frames, expanding tires and discs, boiler making, pipe bending and similar work common in the railroad, boiler and machine shop.

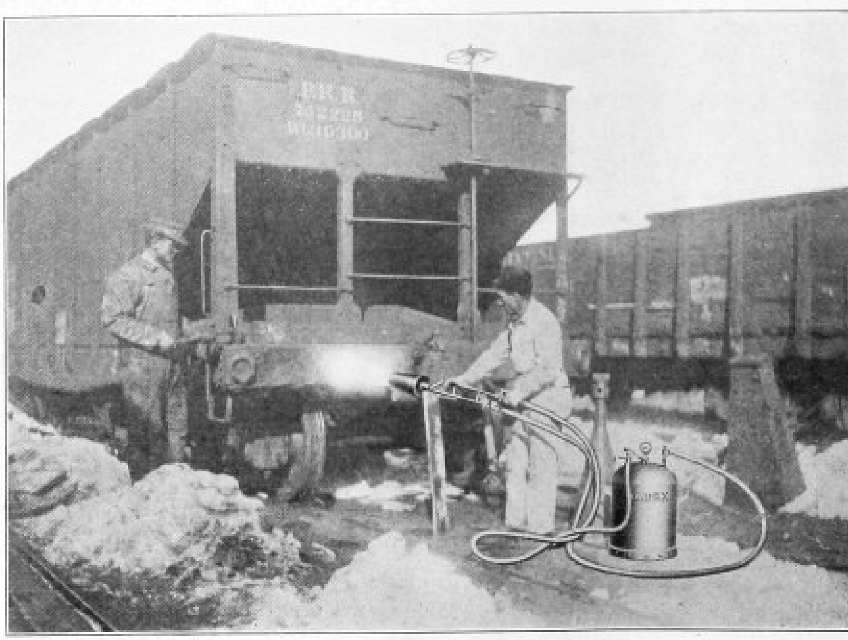
Aside from the powerful and even character of the flame, an important feature is bound in the fact that it can be regulated either to heat a large surface or concentrated on a small area. The rapidity with which work of this character can be done is illustrated by a job recently handled with an ordinary No. 2 burner; a steel plate, ½ inch thick and measuring 6 by 10 feet, was bent to right angles the longer way in fifteen minutes, a space 8 inches wide by 10 feet long being heated for this purpose. The burner is also adapted for brazing and welding work. It is built by the Hauck Manufacturing Company, Brooklyn and New York City.

An Improved Ejector.

In the improved ejector manufactured by the Lunkenheimer Company, Cincinnati, Ohio, the tubes are made of a very hard grade of bronze, especially adapted for the severe service to which ejectors are generally subjected. They are screwed into the body of the ejector instead of being secured by means of



unions. The latter is the method generally employed, but it has been found that tubes become lost or damaged when removing the union; therefore the improved method of construction has been adopted. It is claimed that this ejector is



especially economical because of the improved shape of the tapers inside the tubes, which require a less amount of steam for lifting a given quantity of water than other types of ejectors. To operate the device it is only necessary to turn the steam on full head, and after getting the flow of water established the steam can be throttled to a very low degree. As shown by the following tables, the ejector is capable of lifting water at a high temperature to a great height, and also forcing it against a great head. The ejector is made in sizes capable of lifting from 250 to 1,100 gallons of water per hour at 75 degrees F. to a height of 20 feet, with a steam pressure of 50 pounds.

The following tables give the amount of lift, together with the height that the ejector will force when placed about 5 feet above the water level:

LIFT OF EJECTOR GIVEN IN FEET. FEED WATER 75 DEGREES F.

Pres., lbs.	5	10	15	20	25	30	40	50	60	70	80	90	100
Lift, feet.	3	7	11	15½	21	21	20	19	18	17½	16½	15½	14½

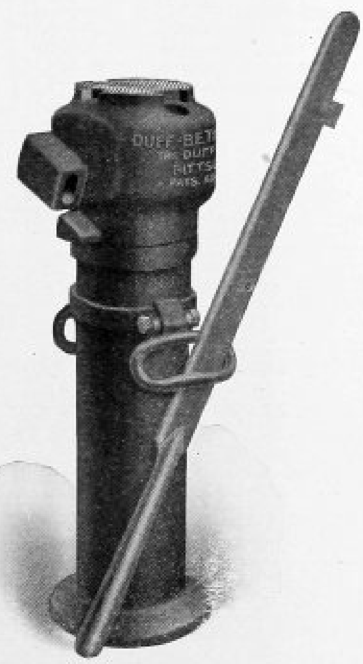
Height (in feet) ejector will force when placed 5 feet above water level:

FEED WATER 75 DEGREES F.

Pressure, pounds.......	20	30	40	50	60	70	80	90	100
Height, feet...........	18	28	36	46	57	66	74	84	92

The Duff-Bethlehem Forged Steel Hydraulic Jacks.

The Duff Manufacturing Company, Pittsburg, Pa., has recently placed on the market a new hydraulic jack, which is from 30 to 60 percent lighter than those of any other make of the same stroke and lifting capacity, and in which packings have been eliminated as far as possible. The only parts where packing is required are the ram and pump piston. Both cylinder and ram have solid bases and are constructed of open-



hearth fluid compressed forged steel. By the construction and location of the valves, these jacks are capable of extending their full length in a vertical, inclined or horizontal position without any special adjustment. A weight of 150 pounds at the end of the operating lever balances the rated lift of the ram, so that one man can readily operate the jack to its normal capacity. There are no operating valves projecting beyond the body of the jack to become broken, and both valves are operated positively by slight pressure on the lever when the same is reversed, causing the load to be lowered. The axis of the pump stroke coincides with that of the pump well in order to insure uniform wearing of the pump packing. Flexible cup packing is used for both pump and ram. It is claimed that the jacks have no tendency to "creep" under a load, as all possibility of leakage is eliminated by the solid construction.

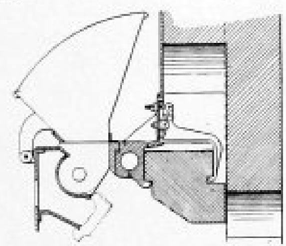
SELECTED BOILER PATENTS.

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

913,697. FURNACE. LOUIS PHILIPP COHEN, OF NEW YORK, N. Y., ASSIGNOR TO GERTRUDE LEVE, OF NEW YORK.

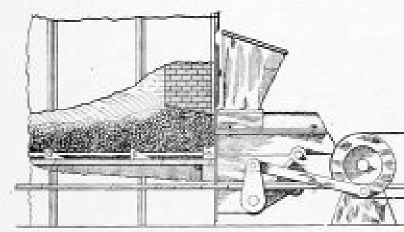
Claim 2.—The combination with a furnace, of a fire wall therefor comprising a plurality of bricks, means for supporting the bricks adjacent one end thereof, adjustable means for completing the support of the



bricks, and for securing said bricks in position, and means extending through a portion of the front wall of the furnace and engaging with said adjustable means, for operating the same. Twelve claims.

913,771. AUTOMATIC STOKER. JOHN M. ROE, OF CHICAGO, ILL., ASSIGNOR TO UNDER-FEED STOKER COMPANY OF AMERICA, OF CHICAGO, A CORPORATION OF NEW JERSEY.

Claim 2.—In a stoker, the combination with a charging cylinder adapted for connection with the furnace to be fed, of a plunger within the cylinder, a ratchet disk connected with the plunger, a pawl, an arm



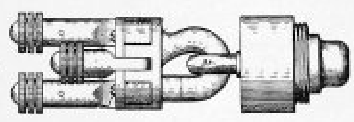
carrying said pawl, means for continuously oscillating said arm, and means operating continuously for allowing operative engagement of the pawl with the ratchet disk during only one oscillation out of a predetermined number of oscillations of the arm, whereby the plunger is intermittently operated. Eight claims.

913,963. BOILER-FLUE CLEANER. SAMUEL H. LIMBERT, OF SPRINGFIELD, OHIO, ASSIGNOR OF ONE-HALF TO CHARLES E. BRENING, OF SPRINGFIELD, OHIO.

Claim 1.—In a boiler-flue cleaner, a furnace well, a boiler mounted within the same, a spray pipe provided with a discharge nozzle extending transversely to said boiler, said spray pipe being rotatably and slidably mounted in said furnace wall, whereby said discharge nozzle may be rotated about an axis extending longitudinally to said boiler and may be moved toward and away from said boiler, a supply pipe extending into the outer end of said spray pipe, and means for controlling the flow of steam through said supply pipe. Ten claims.

914,592. BOILER-TUBE CLEANER. EUGENE METTLER, OF INDIANAPOLIS, IND.

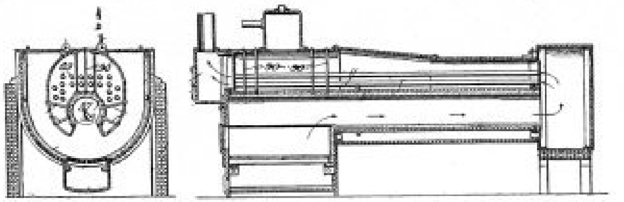
Claim 1.—In a tool, the combination of a main body having a plurality of sockets for receiving fingers and a plurality of alternating wearing-block pockets, of a finger mounted pivotally in each of said



sockets, a pivot pin passing therethrough and through the walls of the sockets, wearing blocks mounted in the pockets and obstructing the said pivot pins, and means for removably holding said wearing blocks in place. Three claims.

914,647. COMBINED BOILER AND FURNACE. WILLIAM J. ELLIS, OF ANDREWS, N. C., ASSIGNOR OF ONE-THIRD TO C. W. SAVAGE AND ONE-THIRD TO W. A. SAVAGE, OF ANDREWS.

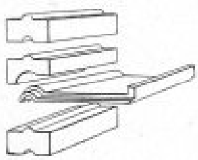
Claim.—A combined boiler and furnace comprising a fire box substantially U-shape in cross section, an inverted U-shaped boiler suspended in said fire box and having a cylindrical lateral extension, said boiler being at both ends, smoke boxes arranged at the front and rear of said boiler, a cylindrical flue extending the full length of said boiler and con-



nected at its opposite ends with said fire box, and said rear smoke box, respectively, return flues extending through said boiler and connecting said smoke boxes, doors arranged at the top of the fire box, and a flue connecting with the front of same box. One claim.

915,195. LINING FOR WALLS. WILLIAM LEMB, OF BROOKLYN, N. Y.

Claim 2.—The combination with a supporting wall, of fire bricks, each provided with a tongue on one face, and a similar groove on the opposite face, binders consisting of a metal plate having a flange on its inner



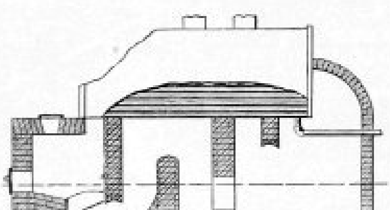
side anchored in the supporting wall, the plate having at its outer part a tongue on one side extending into the grooved portion of one of said bricks, and also having on the opposite side a groove receiving the tongue portions of the adjacent bricks, one of the said bricks being extended adjacent the grooved end portion of the plate into engagement with the other brick to thereby form a continuous outer face of the wall. Two claims.

915,347. BOILER-FLUE CLEANER. RICHARD W. HAMANN, OF ST. LOUIS, MO., ASSIGNOR TO EUGENE J. FEINER, OF ST. LOUIS, MO.

Claim 1.—The combination with a boiler and its setting, of a fluid pressure supply pipe arranged to rock adjacent the rear wall of the boiler setting, a branch pipe leading from the supply pipe through the rear wall of the boiler setting, a horizontally disposed head carried by the forward end of the branch pipe, and there being a horizontally disposed row of perforations formed through the front wall of the head. Ten claims.

915,387. FURNACE. CHARLES SCHWEIZER, OF BOSTON, MASS.

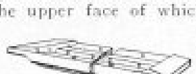
Claim.—In a furnace, the combination with a combustion chamber, of a solid wall at the front end thereof and constituting the front wall of the furnace, a solid hearth integral with said wall and extending downwardly therefrom to a point approximately at the center of the combustion chamber, a wall projecting from the top of the furnace and constituting the rear wall of the combustion chamber, a grate adjacent the



hearth and inclined upwardly for a distance, whence it extends horizontally to said last-mentioned wall, a chamber or space in the rear of the combustion chamber, a second wall in said chamber or space extending from the top to the bottom of the furnace and provided with a plurality of restricted passages, and an additional wall intermediate the aforementioned walls and projecting upwardly from the bottom of the furnace to a point about midway of the beforementioned rear wall of the combustion chamber. One claim.

915,852. HOLLOW GRATE-BAR. ELONSO J. GORDON, OF BIG RAPIDS, MICH.

Claim 1.—The combination in a furnace having a bridge wall, of a hollow blast grate-bar, the upper face of which is equipped with blast



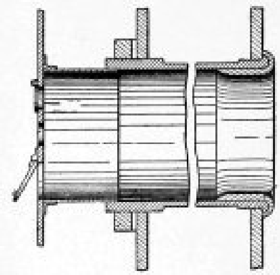
openings, and is provided at opposite ends with divergent apertured walls rising above the upper face of and integral with the bar, the walls extending transversely of the bar. Four claims.

915,427. BOILER. GUSTAV DE GRAHL, OF WILMERSDORF, NEAR BERLIN, GERMANY.

Claim 1.—In devices for temporarily admitting air into a fire-box, the combination of a door frame, a shaft provided at one end with a lever mounted revolubly on the door frame, a fire-door rigidly attached to said shaft, means for fixing the fire-door during its movement in its open position, a collar having notches and shoulders rigidly attached to the end of said shaft reverse from that carrying said lever, a cataract having a piston, a shaft, means for transmitting the motion of said piston to the latter shaft and vice versa, and a collar having projections fixed on the latter shaft, said projections engaging in the notches of the former collar. Nine claims.

915,682. FURNACE. VALDEMAR F. LASSOE, OF BROOKLYN, N. Y.

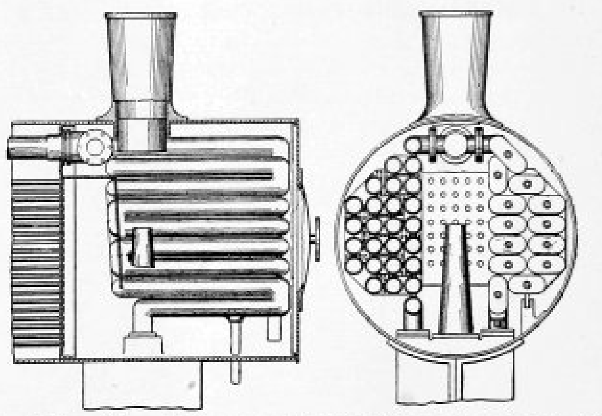
Claim 2.—The combination of a cylindrical drum, front and rear heads connected to the drum and having a threaded opening in each, tubular furnaces having threaded shoulders and in engagement with the threaded openings in said heads, a nut on the shoulder of each furnace adjacent to the outer surface of the front head and bearing against a



packing adjacent to said front head, a bonnet with peep holes extending from the front ends of the drum and inclosing the front heads, damper door over openings in said bonnet for said furnaces, a throat connection for each furnace extending from the bonnet to each of said furnaces. Two claims.

916,180. SUPERHEATER. SWENEY MUNSON, OF FOWLER, COL.

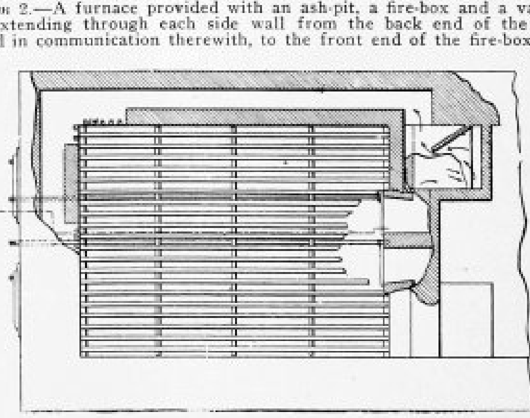
Claim 1.—A superheater, comprising similar sections spaced apart, each of said sections comprising a single coil of cast pipe, the bends of the coil adjacent one end thereof being spaced apart and supported by lugs



integral therewith, and the separate bends adjacent the opposite end being supported and spaced apart by a perforated web integral therewith. Two claims.

916,542. BOILER FURNACE. JOHN MARSHALL ERICSON, OF SALT LAKE CITY, UTAH.

Claim 2.—A furnace provided with an ash-pit, a fire-box and a valved flue, extending through each side wall from the back end of the ash-pit and in communication therewith, to the front end of the fire-box, the



said flue extending across through the front wall of the fire-box, the wall of the fire-box being provided with openings at the corners and middle front thereof, the said openings establishing communication between the fire-box and the flue. Four claims.

Omission.

In our April issue credit should have been given the *American Engineer and Railroad Journal* as the source of the article on page 100, describing the Jacobs-Schupert locomotive firebox.

THE BOILER MAKER

JUNE, 1909

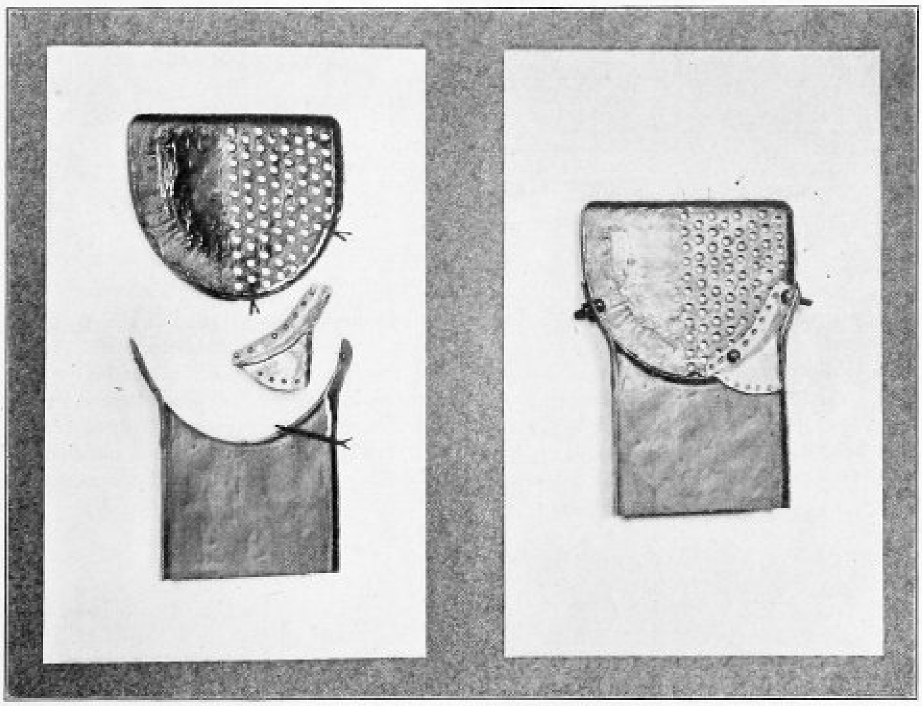
PATCHING A FLUE SHEET.*

BY THOS. F. SEEM.

While employed by the Pennsylvania Railroad Company at Elmira, N. Y., I repaired a locomotive boiler, as shown by the accompanying photograph. This boiler had received a new set of flues; was tested and placed in service, making about ten trips, when a crack about 18 or 20 inches long appeared upon the right side of the inside flue sheet exactly in the root of the flange. A crack also appeared on the throat sheet, on the same side in the root of the flange, about 12 inches long, making a bad rupture.

My foreman, consulting with the master mechanic, decided to place a patch on both sheets so as to wear out the flues before renewing the sheets. I suggested a patch in one piece, which was declared by both officers to be almost impossible; claiming such a patch would be too difficult to prepare, but after explaining how I would proceed it was agreed that I might undertake the job. I did so, completing and testing the same at 150 pounds cold-water pressure. It proved itself a dandy, and both foreman and master mechanic complimented me upon my work and seemed to be greatly pleased with the results.

It will be seen by the photograph that the patch covers several flues. The cracks in both flue and throat sheet are also visible. I was compelled to remove the several flues and tap out the flue holes, screwing in plugs flush with the sheet, which gave me a solid sheet for the patch bolts on the flue sheet. I then cut off the flange on the flue sheet; cutting across the flanges beyond the crack at both ends, and after scarfing both ends as thin as possible to receive the patch I cut the wing off the throat sheet (as shown by the black mark on the photograph), which left the holes in the side sheet to be laid out on the patch after fitting the same.



DETAILS OF PATCH FOR LOCOMOTIVE FLUE SHEET.

The patch was laid out the same as laying out the throat sheet proper, allowing extra metal for the flue-sheet side. In forming the patch I, of course, worked it hot, placing it in clamps and knocking down the short flange on the fire-box side, then took it on the throat sheet block and worked down the throat, which gave me the curve of the flue sheet. The patch was then reversed with the curve up against the flue-sheet block; held there with two strong clamps and flanged down on the flat of the flue-sheet block, which gave me the part that fits against the flue sheet, thus finishing the patch with the exception of drilling and trimming for the patch bolts; ¾-inch patch bolts were used throughout the job.

Time used to place the patch, including removing of flues, grates, front-end netting and replacing same, also placing

* Awarded first prize in THE BOILER MAKER repair job contest.

short-pocket flues in front flue sheet to replace the flues taken out, was about six days. The cost being: one boiler maker and helper $26.50, exclusive of the material used. I am unable to give the cost of the material.

REPLACING THE FURNACES OF MARINE BOILERS UNDER UNUSUAL DIFFICULTIES.*

BY WILLIAM SHOEMAKER.

The subject of these notes is the boilers of a steamship which was, and still is, in service on the Great Lakes. As is usual on these waters this vessel was not in service during the winter months, and as it was thought expedient to make extensive repairs while the ship was out of service, Messrs. ——— & Company were called in by the managing owner for an opinion as to the extent of the work necessary, cost, time required and the manner in which it was thought best to proceed with the same.

An agreement having been reached, on the basis that each of the ship's two boilers should have two new furnaces as well as that the plate below and between the furnaces in the combustion chamber (marked "A" in Fig. 1), the bottom plate of the combustion chamber (marked "B"), and the lower part of the back plate in the combustion chamber (marked "C") should be renewed, the vessel was placed at the dock in the rear of the above-named firm's works. This was done that an air line might be laid to assist in the operations to follow.

It will be seen that the boilers were set facing each other, with a distance of 8 feet 9 inches between furnace ends, while the old Adamson type furnaces, which were flanged and riveted onto the fire-side of the combustion chamber, were 9 feet 6 inches over all. Here arose the double difficulty of getting a 9-foot 6-inch furnace into an 8-foot 9-inch space, and of passing the flanged end through an opening that was too small for it. At first thought one might suggest that this could be solved by taking from one or both of the boilers the lower part of the front head. This was considered, but on account of the many objectionable features, which it is not necessary to enumerate here, was rejected.

The plan then suggested was that which was finally used. The old furnaces were removed by cutting them into three equal pieces, using a pneumatic hammer and making the cut follow the length of the furnace. Where these cuts intersected the stiffening rings a hole of the largest possible size was drilled. By making one of these three pieces taper to a slightly less width at the combustion chamber end, they were all easily pulled out.

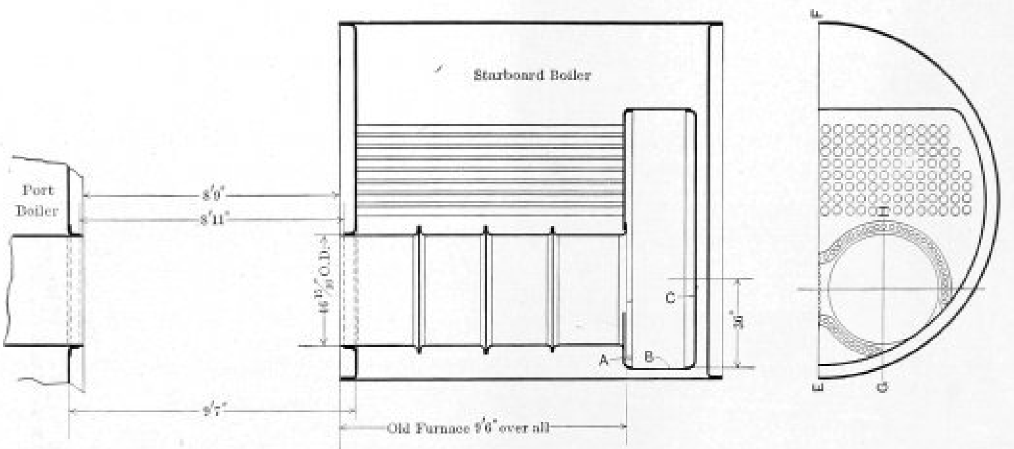


FIG. 1.

The new furnaces were of the Morison type, with a greater length of plain surface on one end than is usual. The object of this was that a piece might be cut out to permit their entrance in the limited space before mentioned. This will be readily understood by referring to Fig. 2. The plate marked "A" (Fig. 3) was flanged out sufficiently far to take in all of the plate removed from the bottom of the furnace. Obviously, the end of the furnace was put into the combustion chamber plain, where it was necessary to flange it in place. (See Fig. 3.) This was done by arranging a small coke furnace on the end of a pipe, the pipe being used for the compressed air blast as well as a lever, by which the fire could be raised, lowered or turned to any desired position. The fulcrum of the lever was carried by a small four-wheeled truck, which ran on a light track that was easily laid in the corrugated furnace. It will

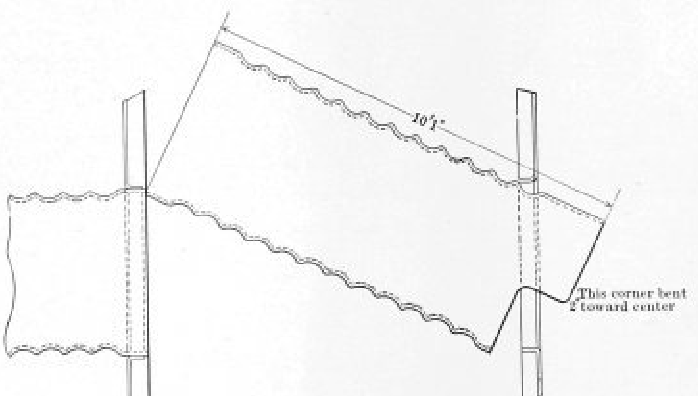
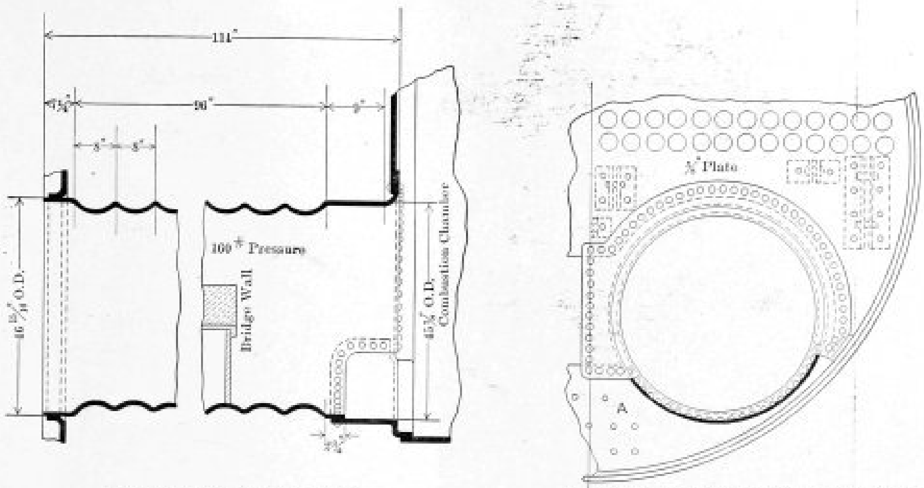


FIG. 2.

* Awarded second prize in THE BOILER MAKER repair job contest.

be seen that the furnace end, having been heated at the desired point, the fire was quickly removed, thus leaving the entire space free for the workmen. As a matter of fact the fire was pulled clear across into the furnace of the opposite



SECTION THROUGH FURNACE

ELEVATION LOOKING THROUGH FURNACE FROM COMBUSTION CHAMBER.

FIG. 3.

boiler, thereby freeing the atmosphere of all smoke and gases.

The work, when completed, was nearly as good, and not much more difficult, than had it been done in the shop. The furnaces, once having been set, were not removed, all rivet

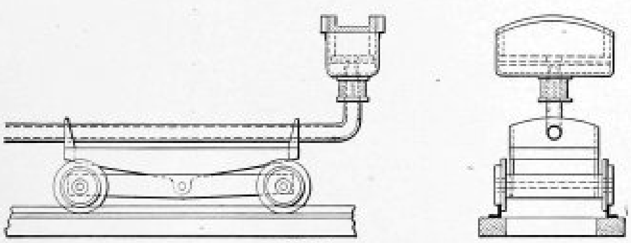


FIG. 4.

holes being drilled in place. Nothing out of the ordinary having occurred in the balance of the work, it will not be entered into farther than to say that the whole job was completed in sixty days.

Superheated Steam on Locomotives.

Superheated steam has now been used on locomotives to a sufficient extent to give reliable data regarding the economy, reliability and ease of operation. In a report presented at the last convention of the Traveling Engineers' Association it was stated that 594 locomotives were equipped with superheaters, 241 of which were installed during the year 1907 and 1908. The committee which presented this report sent a list of twenty-one leading questions relating partly to economy and construction, but mainly to the operation and maintenance of superheaters, to all roads operating locomotives using superheated steam. The replies indicated that the economy in coal consumption runs from 10 to 20 percent. The highest was attained on Great Northern freight engines, which showed a saving in coal of 20 percent, the saving of water averaging between 12 and 25 percent. Furthermore, it was admitted by nearly everyone that the engines using superheated steam, not only handled trains better, and in passenger service, especially, took up the train quicker, but that they can haul a better tonnage than engines of the same size using saturated steam. The average of this increase in haulage is 10 percent, while the maximum recorded was 17 percent. The amount of valve and cylinder oil used on engines is slightly more than is needed for saturated steam, the average increase being 5 percent, only some roads claim as high as 20 percent. The average degree of superheat obtained with superheaters of the smoke-flue type ranges from 100 to 150 degrees F., while with those of the Baldwin type from 30 to 50 degrees is the average superheat. The steam pressure on all engines using superheated steam has been reduced from 20 to 45 pounds below that of similar engines working with saturated steam, and in consequence the cylinders have been enlarged proportionately.

The principal difficulties and troubles encountered in the use of superheated steam occur with the piston rings and valve rings, smoke flues filling up with cinders, ashes, etc., leaking of the large smoke flues at the fire-box end, splitting of superheater elements and leaking and failure of superheater connections. These defects, however, are by no means insurmountable, and are usually reduced to a minimum after a brief experience with the apparatus. So far, the addition of the superheater has not increased the cost of engine repairs per mile. The few mechanical difficulties which have been found have been remedied, and it is expected that in a short time the defects in the existing types of superheaters will be practically eliminated, so that the engine can go from one shop into another without any special repairs being made to the superheater proper.

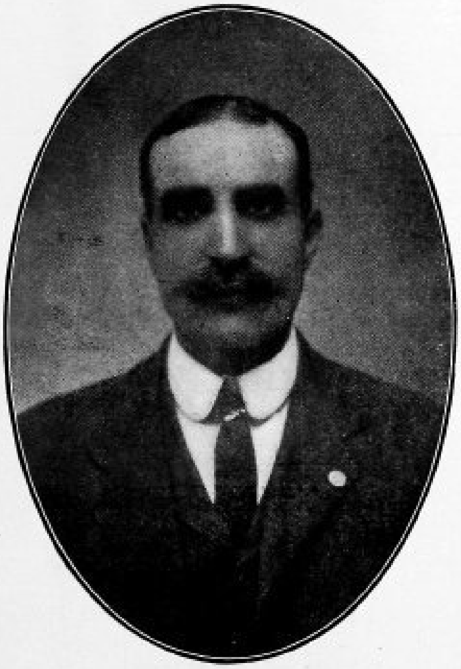
A disastrous boiler explosion occurred on Feb. 19 at the plant of the Liverpool Salt & Coal Company's works, Hartford, W. Va., when a 72-inch by 18-foot horizontal tubular boiler exploded, killing two, injuring three and wrecking a large part of the salt sheds. Although low water was given as the cause of the explosion, the bad condition of the plates was evidently responsible for the disaster. The tube plates and shell were originally 7/16 inch thick. There were five flue stays in the tubes and eighteen diagonal braces above the flues. The boiler was designed for a working pressure of 80 pounds per square inch. The feed water used in the boiler contained a great deal of brine, which attacked the steel plates, pitting the inside of the shell and the tubes. Just over the fire was a soft patch, and a corroded groove followed the girth seam on the inside of the boiler near the soft patch. This was wasted away almost to a knife's edge, showing that the boiler was not in a safe condition.

MEMBERS OF THE INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION, ATTENDING THE THIRD ANNUAL CONVENTION AT LOUISVILLE, KY., APRIL 27-30.

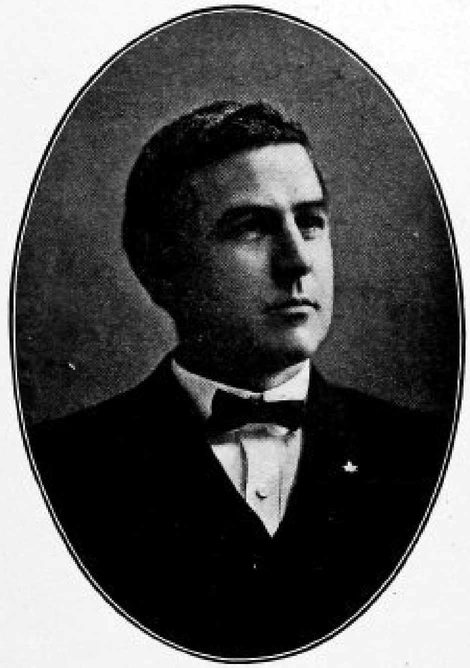
INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION.

Proceedings of Third Annual Convention at Louisville, Ky.

The third annual convention of the International Master Boiler Makers' Association was called to order at 10:30 o'clock on the morning of April 27, at the Seelbach Hotel, Louisville, Ky., by President P. J. Conrath. After a prayer by Rev. Dr. Porter, of Walnut Street Baptist Church of Louisville, addresses of welcome were delivered by Hon. James F. Grinstead, Mayor of Louisville, and Mr. Frederick W. Keisker, president of the Louisville Commercial Club. Responses on behalf of the association were made by Mr. George Wagstaff, past president of the association, and Mr. J. T. Goodwin, chairman of the executive committee.



P. J. CONRATH, RETIRING PRESIDENT.



A. E. BROWN, PRESIDENT.

The president then introduced Mr. Theodore Curtiss, superintendent of machinery of the Louisville & Nashville Railroad.

ABSTRACT OF MR. CURTISS' ADDRESS.

I want to impress upon the members of the association the importance of what they are here for, to consider the boiler, more especially the locomotive boiler. I want to urge upon you the necessity of looking into the different elements which enter into boiler construction. The boiler maker should not limit his energies and his work to repairing the boiler. We hope the boiler maker will so consider the locomotive that he will eliminate the defects in the boiler and give us something for the locomotive that we can rely on more than we can to-day. The boiler of a locomotive is its principal part. You may run with one cylinder on a locomotive; you may run with one driving wheel shy, but I never heard of one running with one flue gone. Likewise the boiler is a brace to the whole locomotive. We don't put the boiler braces on to hold the boiler up, we put the boiler on to save the frame and to save the engine. But that is not the principal part. The principal part of the boiler is to be something that will live as long as the engine, from one shopping to another. Lately, say in the last ten years, there have come to us larger fire-boxes, to give more grate area for heating surface, but with that we have shorter life of the fire-box. I recall some locomotives that are only two years old, which represent a type largely used in the United States, and their fire-boxes are now going to pieces, while there are engines that have been doing the same service, with a little difference in the fire-boxes, that are making from four years to five years to the box. Therefore it becomes the boiler maker to look in and find the cause for this rapid deterioration of the fire-boxes. Some say it is the boiler material. I think that is nonsense. It is the construction of the boiler. Some say it is the high duty. Other kinds of fire-boxes stand that high duty. In closing, I want to urge upon you the necessity of looking into the construction of the boiler and to give us something that will last as long as the machinery; that is, from shopping to shopping.

Mr. J. H. Smythe responded briefly to Mr. Curtiss, and then the president introduced Mr. H. C. May, master mechanic of the Louisville & Nashville shops.

ABSTRACT OF MR. MAY'S ADDRESS.

Your papers are instructive, and you have some points to bring up before this convention that are of vital importance to the maintenance of boilers, and the boiler is, as we all know, the heart of the locomotive. I sincerely hope that in dealing with these you will deal with them as best you may, for we who are in charge of shops like to have our boiler makers keep us straight, in decisions and recommendations, so far as the boiler is concerned, assuming that he, by past experience and knowledge, knows more of that particular part of the locomotive than we who handle the machinery in general do.

Mr. T. C. Best responded briefly to Mr. May, after which President Conrath and Vice-President Brown made short addresses, outlining the work of the convention.

WEDNESDAY MORNING SESSION.

The convention was called to order by the president at 9:30 o'clock, and the annual reports of the secretary and treasurer called for.

ABSTRACT OF SECRETARY'S REPORT.

The executive board organized immediately after the close of the last convention set the necessary machinery in motion for the production of conditions intended to make this meeting more memorable than its predecessors, increase the value of work performed and effect results designed to establish this association upon a policy of such enlarged breadth as to leave no question as to its perpetuity and usefulness. The officers and the members of the executive board, in the discharge of their important obligations, have had to contend with embarrassments and disadvantages beyond the ken of the general membership. With limited sources of revenue available, it was for a considerable time a serious and perplexing problem as to whether it would be possible to meet expectations with a publication of the proceedings of the Detroit convention in the manner desired and contemplated. In its final accomplishment there is cause for congratulation. All should feel a sense of satisfaction in the fact that it was possible to give to the business and mechanical world a volume evidencing how faithfully you labored to produce something of real value.

A. N. LUCAS, FIRST VICE-PRESIDENT.

Unfortunately, we cannot boast with pride of increasing members. Since we met in Detroit we have added to our roll only seven new names, and resignation has removed one, so that the record is not much greater than it was twelve months ago. If from the total number of 372 now upon the books we deduct twenty-seven that are liable to suspension, the result will be a distinct and significant loss, upon which all will need to ponder. The lesson is obvious, and only by heeding what it teaches and getting to work with a strong determination for improvement, will it be possible to reach the goal you set up when the consolidation was effected at Cleveland.

The total receipts were \$591.72; the total disbursements, \$538.05, leaving a balance in favor of the secretary of \$53.67.

ABSTRACT OF TREASURER'S REPORT.

We had in the treasury at the close of the past year and before the Detroit convention, \$102.76. June 23, 1908, I received \$241.21 cash from our secretary, and bills that he had already paid out in his possession amounted to \$89.89, making the total receipts \$331.10. The total amount in the treasury was \$433.86. There has been during that period an expense of \$263.89, leaving a balance in the treasury April 24, 1909, of \$169.88. That is in addition to what the secretary has now.

The reports of the secretary and treasurer were referred to the auditing committee, consisting of Messrs. Laughridge, Wheeling and Troy.

C. P. PATRICK, SECOND VICE-PRESIDENT.

The following committees were also appointed by the president:

Committee on Resolutions—Messrs. Smythe, McKeown, Sr., and Flavin.

Committee on Place of Next Meeting—Messrs. Elkins, Mansfield, Lowe and Stallings.

Committee on Constitution and By-laws—Messrs. Laughridge, Patrick and A. N. Lucas.

Committee on Suitable Subjects for the Next Annual Meeting—Messrs. Hempel, Lewis, Wilson, Ready, Wagstaff, McAllister and Bowman.

Boiler Rules and Formulæ.

The committee on rules and formulæ, of which Mr. Charles P. Patrick was chairman, presented a voluminous report embodying rules and formulæ covering the entire field of boiler construction. Since the committee were not able to have this report published previous to the convention, so that the members individually could have an opportunity to study and discuss the report, it was voted that a committee of five be appointed to go over the report carefully, and before the end of the convention recommend its adoption or rejection or a continuance of the committee. This work was delegated to a committee consisting of Messrs. Patrick, Murray, Wratten, Rapps and Doarnberger.

Standard Tools, Machinery and Equipment.

The committee which had this subject in hand, of which Mr. J. H. Fahey was chairman, spent a great deal of time and work during the previous nine or ten months in correspondence with various manufacturers in the effort to arrive at a standard for various tools, principally punches, dies and couplings. In their report they recommended the adoption of a new standard for punches, dies and couplings which is dif-

MEMBERS OF THE WOMEN'S AUXILIARY AT THE BOILER MAKERS' CONVENTION.

ferent from any manufacturers' standard now in use, and they also recommended a new standard for drift pins, marking tools and pneumatic tools. As the members of the association did not have an opportunity to consider this report carefully, it was voted that a special committee, consisting of Messrs. Kelly, Lucas and Wratten, be appointed, to carefully consider the report and make recommendations to the association before the close of the convention regarding the adoption of any or all of these standards.

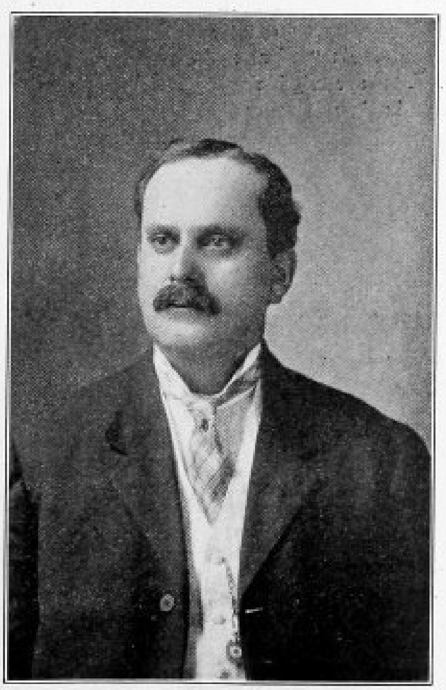
Standard Pipe Flanges.

(An abstract of this paper is published on page 161.)

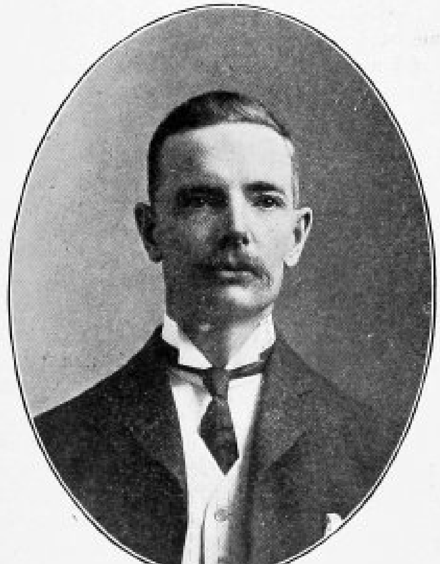
Mr. Best: The American Society of Mechanical Engineers in 1894 adopted a standard flange and standard drilling. These flanges are drilled in multiples of four, so that a valve of any kind can be faced in any quarter. Up until June 28, 1901, the manufacturers fought this standard, but on that date they capitulated and adopted this standard. Every foreman boiler maker in the United States in contract shops has a copy of the standard before him and uses it upon all of his nozzles, flanges and everything else, because the system is absolutely perfect; it is beyond criticism.

Forged-steel flanges are entirely a different proposition. It was not intended that this committee serve on forged-steel flanges at all, because we usually have a standard as given by any concern who handles forged-steel flanges.

After some discussion it was voted to adopt the American Society of Mechanical Engineers' standard pipe flange and to extend the committee on boiler flanges for another year, adding three new members to the committee. Messrs. Wheeling, Filcher and Newdyke were appointed to act on that committee.



H. L. WRATTEN, THIRD VICE-PRESIDENT.



T. W. LOWE, FOURTH VICE-PRESIDENT.

Boiler Explosions.

Mr. J. T. Goodwin presented a comprehensive report on boiler explosions, emphasizing first the responsibility of boiler makers doing strictly first-class and conscientious work, in order to avoid the possibility of explosions due to poor workmanship or construction. The various causes of boiler explosions were enumerated, and some discussed in detail. It was pointed out that while there are a great many causes for explosions, yet nearly all can be detected before the explosion occurs, a fact which leads us at once to appreciate the value of thorough and frequent inspection of all types of boilers and pressure vessels by competent men. Professor Thurston's experiments to determine the effect of low water were described, the result of which seemed to show that the effect of low water is extremely uncertain, in many cases resulting in no injury, but in others resulting in disastrous explosions. Of course the explosion is more violent when there

G. W. BENNETT, FIFTH VICE-PRESIDENT.

is a large quantity of water in the boiler, as most of the energy is in the hot water, and not in the steam in a boiler. The statistics of the Hartford Steam Boiler Inspection & Insurance Company, which were published on page 103 of the April, 1909, issue of THE BOILER MAKER, were quoted to show the number of boiler explosions which have occurred each year for the last forty-one years, and the damage resulting therefrom, and the causes of the explosions in the majority of cases.

Mr. Goodwin: The boiler explosion report could not be of any great service, only as a mere matter of reading. It is a question that you are all fully aware that you cannot take up and treat very severely, only on slightly technical lines. There is nobody you can use for an example, as none of us cares about being advertised in this way. The suggestions in these reports have been made up from authors and people who have had experience on that line and the committee does not deserve much credit, but I want to say to you that the committee was very kind to give me all the information they could. THE BOILER MAKER in this month's issue came out with some data that I had put in this report as a matter of record in our association. It was taken from "The Locomotive," issued by the Hartford Steam Boiler Insurance Society, and I thought it was excellent information, so I have embodied it in this report.

Mr. Wheeling: For the benefit of the members of the association I want to make a remark in connection with the report. I have compared the reports of the Imperial Statistical Bureau of the German Empire with the Hartford Steam Boiler Insurance Company's report, and I find in the last twenty years we had in this country an average of about 300 explosions a year, and I find that the total number of boilers used over there is nearly the same as the total number of boilers used here, as far as we can find out. We have no complete records here. I find that where we have had an average of about three hundred explosions per year for the last twenty years, they have had an average of only seven per year, and it struck me very forcibly that something should be done in this country. I believe proper laws should be enacted to compel proper inspection by competent men. In that country they have laws that cover every single boiler tht is used; no matter where or for what purpose, it has got to be inspected. We do not have such laws and I believe that is where we are short.

As the chairman of the committee on boiler explosions had some difficulty in obtaining reports from the other members of his committee, it was voted that the present committee be discharged with thanks and the subject be placed in the hands of a new committee for the ensuing year.

Which is the Long Way of the Sheet?

The committee recommended that boiler plate ordered the long way of the sheet should be rolled so that the long side of the sheet would be curved, or, in other words, the

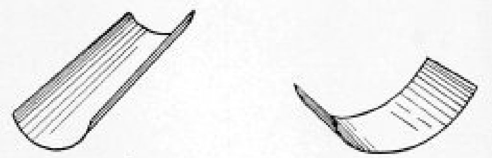


FIG. 1. FIG. 2.

short side of the sheet should pass through the rolls parallel to the axis of the rolls. Fig. 2 shows the correct shape of the sheet after rolling, and Fig. 1 the incorrect shape.

The report was adopted as read.

Mr. Brown: There has been presented to you here this morning by the librarian of the Louisville Free Public Library a key to the technical and mechanical department of the library. You are eligible to get any of the volumes contained in this book, with the understanding that after keeping them a reasonable time you will return the book to the library. These pamphlets are given to you with the compliments of the Louisville Free Public Library.

A vote of thanks was extended to the librarian, Mr. William F. Yust, of the Louisville Free Public Library, for the courtesy extended to the members of the association.

THURSDAY MORNING SESSION.

Best Method of Staying the Front Portion of Crown Sheet in Radial-Type Boilers to Prevent Cracking of Flue Sheet in Top Flange.

(An abstract of this report is published on page 164.)

Mr. Lester: I believe, with all our different practices, that our crown sheet is still too rigid, and if you remove the flue sheet you will find every time the expansion of the crown sheet has commenced to move up in front of your first row of radial stays, sling stays or T-bars. When the front flues are removed the sling stays attached to the T-bar, or straight sling stays, should be removed and put in tension. It would save a whole lot of our trouble. If you have from two to five rows of sling stays, with possibly two T-bars, when you take out your flues there is no tension on them; the tension has all been removed by the flue sheet expanding and the crown sheet coming up with it. If, when the flues are applied, you take all those braces out and shorten them up and put them in tension, when your engine goes out you have still got that room for expansion, and you allow your crown sheet to go up with the flue sheet.

Mr. Brown: Instead of using a jaw brace we use a steel plate, making these holes oblong, using a T-iron suspended 3 inches above the crown sheet by a screw bolt through the crown sheet and also through the T-iron. We attach this by a 1¼-inch turn bolt, allowing at least ⅜ inch on top and bottom for expansion. By making this hole oblong we are not taking any of the strength away from the brace. We have the same area of metal on each side to support it. We make it long enough to give plenty of expansion. We ought to go back two more rows of crown bolts. We have not sufficient play for this sheet to come up, and I believe a good addition would be one more T-iron. The T-iron we use is 39 pounds to the lineal foot. It is supported by a screw on the roof sheet. I stay all radial stay boilers. I think if we could recommend an additional amount of flexible stays there it would be an improvement. The flexible bolt is a little bit difficult to apply in a radial stay boiler, as we lose the thread in the sheet on the side. This relieving of the expansion on radial stays at this particular point, in my experience with high-pressure boilers, is very essential.

Mr. Borneman: I have flat, flexible radial stays and boiler supports of a coupling design. That, I think, has overcome the cracking of the flange of the flue sheet above and also at the side, and also I have overcome 50 percent of the bottom flue leakage. I have had this in use for eighteen months. It is practically a flexible stay used as a brace on the bottom of the flue sheet.

Mr. German: We are experiencing a lot of trouble on the Lake Shore in the cracking of flue sheets in the top flue holes through the flange and the rivets, and also in the knuckles of the flange. We are welding these up. We have about seven engines with these cracks welded, and they are running very successfully. There is no doubt that it is the frequent working of the flues that causes this stress on the sheet, and it releases itself as an upward movement. We have ten engines that have high-pressure boilers and have two solid front bars on them. The bars are fastened with a bolt just the same as a crown-bar boiler, and in between each of the crown-bar bolts there is a hole drilled in the bar ¼ inch, with a radial bolt running through the top with a nut underneath it. These bars are nine years old, and we have not had a flue sheet flange either go up or crack on the boilers.

Mr. Wandberg: I am greatly in favor of the T-bar or crown bar in the front part of the crown sheet. We have had in service in Minnesota and Dakota two boilers practically of the same power, although not exactly the same type, one having the eye bolt and strap brace; but the strap brace is slotted, so as to give it a chance to raise and lower with the contraction. Yet at the same time these boilers are not giving us the satisfaction that the boilers are that have the double T-irons on. We have no trouble with the cracking of the top of the flue sheets on these engines that have the T-bar. I am strongly in favor of increasing it to three T-bars, and I believe it would greatly overcome our troubles. In good water, new boilers have not shown any sign of cracking, but in bad water new boilers began to crack in less than nine months, due probably to working flues more frequently. This cracking is often caused by the boiler makers driving their expanders in as far as they can drive them when the engine is hot.

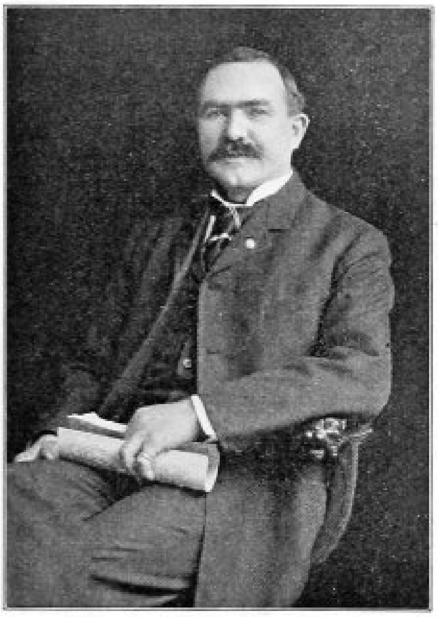
Mr. Kelly: I do not think the trouble is all due to the staying of the crown sheet and the flue sheet. The flue setter starts in there to set the sheets, and the crown sheet is perfectly straight. Some flue sheets have ⅝-inch bridges and some 11/16 inch. The finer and smaller the bridge the worse it is for the sheet. They start at the bottom and work up. Where is that sheet going to go? You are crowding it up by degrees, and where is that stress going? It is spreading out. It can't go out on the side, so it all goes up. Then just as quick as that sheet becomes warm it works upward. When you have plenty of leeway to allow the crown sheet to go, all right, but if you don't the crown sheet becomes solid and goes twice as fast. It is up to us to set those flues and make our flue setters distribute that load. I believe the cracking of our flue sheets on top is largely due to working of the flues in the roundhouse. We had an Atlantic type of engine—one of the first built. It did not have T-bars, but had eye bolts. It seems to me that that engine with eye bolts and sling stays did just as well as a good many we have with T-bars. There were five rows of eye bolts, twelve each side of the center. I find that the flue sheets with eye bolts, that had good leeway top and bottom, have been doing as well or a little better than T-bars. I believe the flue sheets should be stayed, the front flue sheet to the back flue sheet. We have engines with 350 flues, with the bottom flues all complete, and we have a man on one division that is in bad water, where the flues last, maybe, four or five trips. We have cut out forty-five flues on the bottom of the engines and put in suspension stay rods, and we are having fine results.

J. T. GOODWIN, CHAIRMAN EXECUTIVE COMMITTEE.

Mr. Lucas: I believe our trouble began from the time we started to put in copper shims. When we tram our flue sheets before we work our flues, the sheet has stretched one-eighth, and in working them in the roundhouse we find they have stretched them again one-eighth. Where you work your flues often the stretch continues to grow, until it is almost impossible to expand and calk your top flue, due to the flange coming down. I don't think staying the flue sheets from sheet to sheet will help to stop it, and I don't think three T-bars will stop it, for the simple reason that our flange comes down from the first bar 4 inches from the flue sheet, and if I put another bar on there the crown sheet would go up.

Mr. Doarnberger: We tried an experiment some time ago by putting in an installation of flexible stays, six rows clear across from the crown sheet down the other side. We put crow-foot braces on the flue sheets, but we did not rivet them to the boiler. We put them on there with oblong holes, that let the load take the pressure towards the fire set. That sheet was capable of moving at that point. The only places it was tight was where it was fastened to the side sheet and the crown sheet. This was a 200-flue engine with a ⅜-inch flue sheet. After the boiler was on the road we put the trams on, and it did not move a thousandth part of an inch. The engine has been in service for seven months, and the sheet has been worked constantly right along, and that sheet has not moved a particle yet, and it is free to move.

Mr. Rearick: We have used a sling stay which has lots of room for expansion, but the top of each of the flue holes cracks up. That doesn't look as if the expansion is on the knuckle where the expansion would be up and down, but it is from the flue hole out at different places. We have the braces and sling stays four rows back and yet we have a cracked flue



FRANK GRAY, TREASURER.

hole. It is not the working that causes this trouble; it is in consequence of the expansion.

Mr. Brown: I fail to comprehend where the rolling of flues is so decidedly effective out near the flanges. These cracks do not run vertically. They run with the flange and crack immediately in the flange. We must provide for expansion. The flue sheet has an upward tendency of expansion as the boiler becomes hot, and it travels no other way than upward. The flange in its movement from the heat and cold produces a "breathing," from the fact that it is rigid on the top and has no place to go. It must do something, consequently it will leave a stress there and it will go sooner or later. This "breathing" backward and forward will eventually give way on the weaker side, which is the inner side of the box, and at the immediate root of the flange. Some place for this expansion must be provided over the top of the flue, and when Mr. Doarnberger said six rows it met my approbation. We found this T-iron bracing to be the beginning of a better end, but I will not say to take two rows; I will go on record advocating four or six, and I am thoroughly of the opinion that the result will be good.

Mr. Hempel: So far as the staying of the crown sheet is concerned, it has absolutely nothing to do with the cracking of the flue sheet. The staying of the crown sheet is simply to keep the crown plate from coming down. The provision that is made for expansion through the slot, or any expansion stay, is simply to provide for the upward expansion of the box. This has nothing to do with the cracking of the flue plates from the rivet hole out to the flange. The real cause of the cracking of these plates is due to other causes, possibly to the overworking of the flue. There is a stress put upon the plate, and each time you work the flues you put on more, and it must go somewhere. Eventually the crown plate, put in at 70 inches, when removed would be 70¼ inches. The crown plate has never come down. Put a straight edge on the crown plate from the rear and it is straight. Your flue sheet has grown from 70 to 71, maybe more. Where you must work your flues more you naturally have more trouble. But I hold that the staying of the crown-bar box has nothing to do with this cracking. If we want to get away from that cracking we must make other provisions, and the only way to do that is to send that stress some place else; take it away from this point. With a Belpaire boiler, you all know what takes place there. With the radial stay it cannot go any other place except at the top, because there is where it is loose. Mr. Kelly says "I believe in staying the plate." Why? Because he has overcome the difficulty in one place and he has put it in another, and now he is after that place. I am as far at sea as anybody else, but I say, no matter what you do, you eliminate one difficulty and get into another, so I am thoroughly convinced that the staying of the crown plates has nothing to do with the cracking of the flue plates.

Mr. Johnston: In regard to the breathing of the flue sheet, why doesn't the door sheet breathe? There is no movement of the door sheet.

The President: I have removed door sheets that were broken from the top staybolt hole around in the flange.

Mr. Johnston: In one or possibly two percent of your engines, but in regard to the breaking and the cracking of the flue sheets, I believe there is only one solution, and that is corrugation over the top of the flue sheet, below the flange, between the flues down as far as the flues, and let that corrugation come and go.

Mr. Brown: I attribute this cracking of the upper row of flues to abusive operation, and I am not of the opinion that we need anything bigger than a three-quarter bridge. I don't think we need any more surface than 2½ inches from the top of the flange to the center of the flue holes, provided that will act as an avenue for this expansion, which is so damaging to that part of these high-pressure boilers. I mean the radial stay boilers.

Mr. McKeown, Sr.: I admit that this T-bar is a very good stay. It is all right. I do not make the angle of the sheet five or six-inch radius; if you do, you have the trouble horizontally across the sheet. We don't work the flues at all at the top; there is no occasion for it. Another thing, we are putting in flues with a wider bridge. If you have a sheet which you have to renew, the oftener you straighten that sheet up, you upset it, and it goes together. If we make an oblong hole we ream it out. The top flues are not calked very often. Sometimes on the door sheet we have a little trouble, but that we attribute to the material. What we want to take care of is the cracking out of these flue holes.

Mr. Rearick: I claim the evidence doesn't show it is the expansion alone from the flue sheet, but it must be the crown sheet.

Mr. Gray: In my estimation, the only way that we will ever prevent those sheets from cracking at the top is to change the design of the sheet. I think the boiler makers and mechanical engineers have been holding on to that design long enough. They cannot, with the present design of flue sheet, prevent cracking at the top in the course of time. There is no doubt but that excessive working of the flues has more to do with it than anything else, and the setting of the flue sheet results more or less in damage in one point. I have found in my experience that the less flues are worked in the roundhouse, or the better they are worked, the longer they will last. We have been working on flues entirely when the engines are hot, before they are washed.

Mr. Elkins: We are not putting in any flue sheets with less than an inch bridge on any style engine. When we renew the front flue sheet we take it out on purpose to put in an inch bridge. We are having the best of success. Some of the engines after they have run three years have not gone up at all, where before that every three years the flue sheet would have to be renewed. We don't allow the roundhouse men to have rollers at all, and we use the best boiler makers we have in the round house.

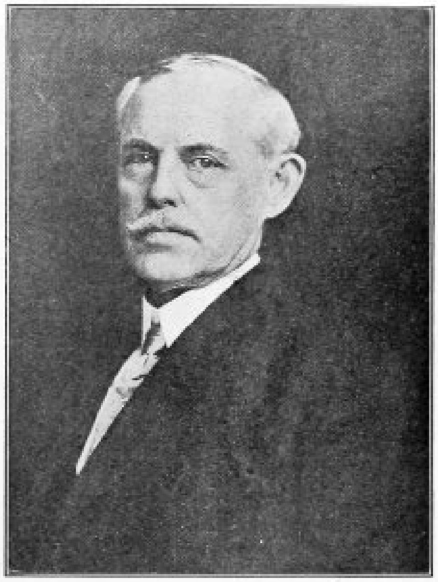
Mr. German: At the time you are expanding the flues, it has a tendency of forcing the sheet up, but with regard to this class of boilers with the crown bars on, I think it is the design more than the working of the flues, while I believe that the working of the flues has a tendency to crack the upper flue hole. In the boilers that we are having trouble with on the Lake Shore Road, the part from the sheet to the first sling stay, which is 7½ inches, leaves that part too flexible altogether. It is not rigid enough to resist the upward movement of the sheet through the working of the plate.

Mr. Laughridge: I will have to concur with Mr. Lucas and Mr. Hempel that the working of the flue has more to do with it than anything. We had twenty-five engines which ran a year and a half and the flue sheets were all cracked. Then we took the skeleton crown bars out and threw them away and put the straight stay in and dropped the top row of flues out, making it five and a half inches in the center to the first row of flues, and it decreased as it came to the outside. Those fire-boxes have been running now for eight years and they have never had a crack in them. We changed the engines to another division, where the flues are not worked very often, and we have never had a crack, and I am satisfied that the working of the flue is the greatest cause of the cracked flue sheet. Our practice of late years is that, we never allow the roundhouse men to work a flue hot. If there are four or five rows in the top that do not need working, they begin on the top row that does need it and work three or four rows down and then work around and around, and finally wind up in the center, to allow the sheet to drop in. In that way we are getting good results, and we have not had a broken flue sheet in eight years.

Mr. Sarver: We have most all Belpaire boilers and we very seldom have a flue sheet cracked at the top, but we have those oblong holes, and what flue holes are cracked are those in the top row. There are two rows of flexible bolts next to the flue sheet. The sheet goes up and relieves those bolts, and the outside of the sheet does the cracking. We have quite a number of sheets that crack on the outside on the Belpaire part of the boiler.

Mr. Lowe: On the Union Pacific Railway we have attempted almost all of the different methods which have been described, and we have come to the conclusion that we have got to look after the cure of this trouble in another direction, and at present we are experimenting along those lines. We believe that most of our trouble in the fire-box is attributable to the circulation of the water, and we believe that the circulation next to the back tube sheet is all one way; not so at the door sheet, where the circulation is not so violent. I believe that we can cure a great deal of this trouble by providing a circulation which will be both downward and upward, the steam arising upward; and the more heated water coming to the top, will be provided a means of getting to the bottom to supply the different points where the most excessive heat forms. Now, we believe that the most excessive heat is right up at that back tube sheet, whether at the bottom or the top, and wherever the greatest excess of heat is, that is the point where we want to get the water and where we have not got it. I don't think that the sectional expander or the staying of the flues plays any important part with the failure around the circumference of the tube sheets.

Mr. Lucas: We are here to adopt something in regard to this question. I believe that the method of the crown bar across the flue sheet, in order to brace the front portion of the flue sheet, is as good as any. It has been said that flues are only calked in the center. At the same time, when the flues are renewed, they have to put in larger copper shims all over; it seems to be stretched all over and the flange seems to be coming down. Take the engine that is giving the most trouble out of service and put her in stationary use and the trouble ceases immediately, going to show that conditions are the cause of all these troubles; where we are continually working the flues, the flue sheet is going to



HARRY D. VOUGHT, SECRETARY.

pieces rapidly. Where we don't have to calk the flues, our flue sheet stands. I cannot say that we are having much trouble on our system. We are getting better than 250,000 miles between flue sets. In the last three years we have put in about three fire-boxes.

Mr. Linderman: We had a class of engines that cracked half of the flue sheet in seven months. We patched them until we got the mileage out, and then took the sheet out. We then put in flexible staybolts from the mud ring up, and in some engines six rows back. These engines are running, some of them, yet, three years, without the flue cracking. We have one Atlantic engine that has an entire installation of flexible staybolts without a rigid bolt in the boiler. That engine has been in service a little over two years, and the last time I made an examination there wasn't any perceptible sign of the flange coming down at all. The expansion in that flue sheet is not at the top altogether. It goes to the top because that is the weakest point. Your sheet wants to radiate from the center. There is no way for it to go but the weakest point. By using a flexible staybolt that gives a chance of expansion on the top, and we found that that helped us out a good deal.

Mr. Kelly: About two years ago I did some experimenting with the corrugated sheet. In putting in the corrugation I could not put in all the top flues, so I left out eleven or twelve and substituted stay rods. That stopped the sheet from cracking; the flues did not leak as much.

Mr. O'Connor: At the first introduction of the radial stay they were all rigid. Those locomotives came to our Western country, and in a very short time we had trouble with the flue sheet cracking. They not only cracked around the knuckle and the flange but they cracked the other way, too. I had occasion three weeks ago to put on a patch 24 inches long, cracked around the flange. Whether that was due to the flanging or some defect of the steel it was a hard matter to determine. I went into the engine myself to examine the crack, and I saw that there was very little grooving there, that it was a plain crack that might have been done by flanging the steel at a blue heat. To eliminate trouble with the radial stays we left out three rows and put adjustable stays in, and we got some satisfaction out of that. Still, we wanted to improve further, and we left out five rows and had better conditions. Finally, we commenced to allow more margin between the flue hole and the knuckle

B. E. D. STAFFORD, RETIRING PRESIDENT SUPPLY MEN'S ASSOCIATION.

of the flange, and that helped a great deal, and then in our section of the country we made the hole on the top oblong, and that did good service. In those classes of engines we have had trouble in cracking the rib from the flue sheet up and around the flange, and I have made a personal investigation, and found that in a certain class of locomotives, of which we have twenty-five, there was no provision made at all for any release of expansion, and we had more trouble in those engines than in any others. I believe out of the twenty-five now there are only ten that are not cracked, and they are practically new engines. I have oblonged the hole above in the T, and in every one of these engines I had to patch them and then made preparations to release the expansion. As the engines that were not cracked came in for general repairs and renewal of flues I did the same thing, and I have prevented them, I believe, from cracking at the root of the flange. The Chicago Northwestern has made provision by leaving out the margin, which is good. I have been with them twenty-one years, and I know that that has been a vast improvement.

Mr. Berry: I think, as far as the staying of our sheets is concerned, that it will be impossible to eliminate all cracks from the stays, no matter what flexibility you give them. We have found that better results can be obtained by dropping one row of holes from the top than by any other method. Still we are getting some cracks. I think there is something further than the staying that has to be figured out to overcome this difficulty.

THURSDAY AFTERNOON SESSION.

The convention was called to order by the president at two o'clock and the discussion of the subject of the best method of staying the front portion of crown sheets to prevent the flue sheet from cracking was resumed.

Mr. Wood (explaining the advantages of his patent corrugated flue sheet and fire-box): At the Buffalo meeting of the Boiler Makers' Association, I was asked if I would try to do something in the shape of flanging to eradicate the troubles talked of this morning. I claim that this flange—that is, the top sheet—not only increases your heating surface, but it strengthens the flue sheet, and it not only strengthens the flue sheet, but it takes out that buckle, that was spoken of this morning, in the center and allows it to expand and contract in unison with the front tube sheet. The front tube sheet is flanged in the same form. These tube sheets should be of identical thickness, so there should be no more tension on one than on the other. We have increased the area 50 percent in the first place. It has five places in which to expand before it would reach any vulnerable point. The sections we have made 1¼ inches deep. I contemplated making them considerably deeper in the first instance, but I reduced them after making tests on the testing machine. We can elongate that section 1/20 inch with 900 pounds and it will go back to its original position every time. You can pull it fifty times and it will go back to the same position. Take the same section on a straight plate and it takes 15,300 pounds to elongate it 1/20 of an inch, and after it is elongated it is permanently set and won't go back. This shows the elasticity of the section. It is only an inch and a quarter deep and there is not a great deal of cavity for any sediment to rest in. In working five months we have found no broken stay-bolts, and we find, as I said, the scale which tends to adhere to the plate drops off. We make these 5-inch centers. By making them 5-inch centers we dispense with 350 stays in the same size box, which is am important factor. We increase the diameter of the stays to one and one-eighth inches instead of one inch. The reverse section is only 13/16 inch. I have had a large experience in flanging, and I suppose that is the reason the boiler makers asked me to take an interest in them. I devoted two years' time to studying it before I allowed my name to go out with it or allowed anyone to see it. It is there for what it is worth, and I think it is the future box.

Mr. Goodwin: Why do you put the crown bolt as it is?

Mr. Wood: Mr. White, the mechanical engineer of the New York Central, would have me put in three rows of sling stays, but I didn't see any use of it at all. They might as well be left out. I want to make another statement; that is, in regard to the wrapper sheet. I made the wrapper sheet ⅛ of an inch heavier than it used to be. I did it for this reason, that I thought I would have eleven threads in that wrapper sheet instead of nine, and that would give my stay a firmer setting, and I wanted my stay to be firmly placed and the bolts to do the work of contraction and expansion. I did not carry these corrugations to the bottom because I did not want them to run into where the fire comes. I wanted that to be clean and clear, so that no clinkers would get on the corrugations. I claim that these corrugations going down the side assist the circulation of water by making it more rapid, inasmuch as it divides up the column of water in this large box and allows the gases to escape so much quicker. We have not taken up much room. We have not changed the position of the stays in any shape or form; only made them so we could dispense with 350 stays in the box. They are on the flat surface just the same as they were in the flat box. The only thing it does here is that you have got to have the waterline 2½ inches higher than what it was before. As to the safety factor, that complies with the New York State laws just the same, but it not only gives increased heating surface, but it makes it fifty percent stronger and takes up that buckle in the center that the gentleman was speaking of this morning, because you have got a stiffer plate.

Mr. O'Connor: Do you claim that that will take considerable of the rigidity off of the bead of the flue?

Mr. Wood: I consider that there should be a good deal less trouble with the flue, especially if both flue plates are made of the same thickness, so they can work in unison, one with the other. The tendency of the tubes to expand must go towards the fire, and in doing so you see they can both come together; there is the same leverage on both sheets. Three engines with this type of box have been running on the New York Central for five months. There is not a shadow of any failure in any shape and not a broken stay. These engines have been running against engines of larger capacity, and according to the reports they do not burn any more coal for the same work than the larger engines do, therefore it shows the balance is in favor of these engines. We find that on account of the increased fire-box surface we can leave the doors on the latch all the time, blowing off steam.

Mr. Hempel: I would like to ask a few questions in regard to the cracking of side plates, and later on as to the cracking of the plates on top. In fire-boxes longer than 72 inches, you find that the expansion only runs 36 inches from each end and in the center of the box it has a tendency to buckle. It is held that there is great stress put upon the plates while they are hot. Now, I hold that this is not true; that there is no tension there, that there is a compression, and that the compression shoves the metal in and it tumors upward, forming a bulb. If there is no tension and there is a compression in here, your idea is to eliminate that by the corrugation?

Mr. Wood: Exactly, and I do so. I want the stay to remain permanent and I want that plate to be perfectly free to move.

Mr. Hempel: What we have now will not eliminate the cracking of the flue plates on the top, and it is possible that Mr. Wood's idea will eliminate that, and it is also possible that the corrugations will eliminate the cracking of the side plate; and as you stated a minute ago, as far as your mud ring is concerned, it comes down too low and is cold and there is no great amount of expansion or contraction. The mud ring will not work either way with the corrugation that close to the mud ring. But the subject we are on now is the top sheet.

Mr. Wood: We have increased that 70 percent.

Mr. Hempel: What method can we employ to prevent that cracking?

Mr. Wood: I do not think you can employ any better staying than that. I am not very much in favor of the T-iron and the stays, the same as you use in the Atlantic type or the Pacific type. I do not hesitate to say there will not be a broken stay in that box in a year.

Mr. Hempel: Now, so far as the cracking of these plates is concerned, there is only one way to get away from it. It is to redesign the plate. This might possibly do something towards eliminating that, but I doubt very much whether it will wholly overcome it.

Mr. Brown: Do I understand Mr. Wood to say that this corrugation is a new device? I refer to the side sheet alone.

Mr. Wood: Corrugated side sheets have been working on the Chicago Northwestern, and there have been side sheets used some thirty years ago, I have been told by Mr. Wells. But while the corrugations did remarkably well, he did not have them in the proper form. In other words, there was an acute angle which caused them to crack at the angles. There is no angle in this at all.

Mr. Brown: I served my time under Mr. Reuben Wells, and in the railroad world he was at the top round of fame. But he fell when he put the corrugation in. Reuben Wells, in his experience as master mechanic on the J. M. & I., worked from Louisville to Indianapolis and got this idea of corrugation in the side sheet. I have the pleasure to say that I was one of the men that formed the sheets for him. The distribution was two rows of stay-bolts between every corrugation. This was an ogee fire-box, and all he asked for was the corrugations to extend a reasonable distance above the side bearings to an appropriate point in the corrugations. His side sheets were only in service a very short time. He had a patch on every one, with the exception of those adjacent to the flue and door sheet.

Mr. Gray: In regard to that corrugated flue sheet, I do not see that this is going to eliminate our trouble a particle.

G. N. RILEY, PRESIDENT SUPPLY MEN'S ASSOCIATION.

Our front flue sheet cracks around the heel of the flange, around the bottom. The front flue sheet never gets any work done on it only when we are resetting the flues. The back flue sheet is being continually worked and the flues expanded, and in my estimation the corrugation would give out there sooner than the ordinary straight flue sheet.

Mr. Laughridge: It has been my experience with corrugation in the fire-boxes that the life is limited, no matter where you put the corrugation. I once made the experiment when renewing a flue sheet of flattening the flue sheet down and dropping out fourteen flues and putting an ogee down from the crown sheet to the flue sheet, and the ogee broke at the corner. That sheet finally broke because it provided a place for the expansion and contraction to exert itself. The same thing may be expected if you corrugate a side sheet. As Mr. Hempel has said, when the sheet expands the metal is under compression, but it is when it contracts that the mischief is done. Then the sheet breaks on the fire side in the compressed surface and cracks on the water side in the convex surface. A sheet will corrugate itself naturally in a bad-water district to some extent.

Mr. Kelly: I don't agree with Mr. Wood about placing the stay-bolts in the top of the corrugations. I think they should be in the bottom. When they are in the bottom of the corrugation the head is protected from the fire, and on the top they are in the fire and will always leak. We are corrugating all the side sheets on the Northwestern from above the ogee to the stay-bar with a ¾-inch radius, with the stay-bolts in the bottom. This was applied on the first engine five years ago. That engine, previous to that time, cracked a set of sheets in ten or twelve months. The corrugated side sheets are still running. On bad-water divisions the straight sheets come out every nine to eleven months. I think I ought to advocate the corrugated side sheets, because the Chicago Northwestern had corrugated side sheets thirty-five years ago, and had the crown sheet corrugated thirty-five years ago. Our stay-bolts never leak. When they were on the straight side sheets they leaked all the time. You take out a sheet and the stay-bolts leak just the same as when the sheet was put in. I take the stand of advocating the corrugated side sheet against the straight side sheet. When you can show a railroad that you can increase the life of a side sheet 2 to 1, you are showing them that you are saving them some money.

G. R. SLATE, SECRETARY-TREASURER SUPPLY MEN'S ASSOCIATION.

Mr. O'Neal: I have had a great deal of experience with corrugated crown sheets. When I came on the Chicago & Alton Railway, there was a man by the name of Mr. Holland that had also experimented four years with corrugated sheets. I found that some of his sheets had been in for a number of years, and my attention was called to them, and I considered he was moving in the right direction. I experimented on a little depression in a corrugation shape. It was more of a corrugation than anything else. I put in as high as eighty-five fire-boxes on that road, all corrugated. I corrugated some of them in the crown sheets, and some of them gave good results, I understand. I also put this in without stay-bolts in large patches as high as 36 inches square. After running those patches for some time I found that some of them had cracked. I knew what was the cause of it; the steel was 65,000 pounds tensile strength. I then put in steel of 48,000 pounds, had it made on purpose, and tried that.

Mr Fisher: We have the best water, I believe, there is in the country, and flue sheets crack even in that good water before the flues are expanded to such an extent that the expansion is the cause of breaking the flue sheets. There is one particular engine that I have had trouble with out of a class of which we have five. The flue sheet was giving more or less trouble all the time, and finally cracked. I investigated, and found that the water-glass was placed in such a position that there was only 4 inches of water over the flue sheet at the time the water was in the water glass. I believe there was not a large enough volume of water over the front of the flue sheet to prevent crystallization.

Rules and Formulæ.

The committee appointed to check up the report on rules and formulæ recommended that the report be accepted and adopted. This report was accepted by the convention, and the committee discharged with thanks. Subsequently, at the suggestion of the secretary, it was voted to have the rules and formulæ published in pamphlet form.

Best Method of Caring for Flues.

(An abstract of this report is published on page 166.)

Mr. Doarnberger: With an auxiliary or reinforcing sheet, the flue sheet is only ⅜ of an inch thick, and the flue is put in and rolled back without any beads. If the flue breaks down I reach in there with a tool and cut that flue off and pull the short end out, and I slip in there and roll it back again without disturbing any part of the front sheet. I have got a new end on the flue without taking it out. That can be done very quickly.

Mr. German: I would not like to take the responsibility of letting a boiler go out of the shop with a single sheet with no beads on it. We have experience every few days when an engine comes in with three or four beads gone, and we notice that the sheet is beginning to bulge. How much more mileage do you get out of this boiler with the auxiliary flue sheet than we do with a single sheet when it is kept free from scales?

Mr. Doarnberger: Our average is not over 5,000 miles on a single-sheeted engine with regular beaded flues. The first engine without beads was put into service six months ago. They have made in the neighborhood of 83,000 miles to the first of this month, and they are still in service.

Mr. Hempel: Whether it would be permissible to permit an engine to go out into service with no beads on depends on the flue. That is as to the factor of safety under your laws. If you permit an engine to run under the percentage of safety, it would certainly not be proper to let the engine be in service. But if you have a new set of flues, and can retain those flues the full thickness, there is no danger, so far as I can see, in Mr. Doarnberger's idea. What he has taken away from the flue sheet on the bead he has put in the reinforcing. That is the same as if you had beads. I believe some good will come from just such construction as that. It is not necessary to remove the flue, but simply remove the piece and take it out, which is a very good idea.

Mr. Doarnberger: When these flues went in service the purpose was to take the load off of the flue sheet and transmit it to the auxiliary sheet, and to have the vibration take place there instead of on the flue sheet. On these particular engines it was claimed that the beads had burned off, but that there was less leaking than with the beads on. Then I reduced the flue sheet from ½ inch to ⅜ inch, and instead of the beads burning off they were doing better than when they had the beads on.

Mr. Lucas: We are all well aware that when our flues are in such condition that the bottom beads are all off we are not getting very good service generally. We judge the condition when the beads come off and put in a plug or two. That is a temporary method of getting the engine over the road from week to week. We don't propose to let the plugged flue run a day longer than we can help. He is talking about cutting them off this side of the inside sheet. It is not very easily done.

The President: The idea is that the flue that is already in there holds the inner sheet in its place with a bolt into the other one. The piece is just to protect itself in there. The load is transferred on to the auxiliary sheet.

Mr. German: We have adopted a system on the New York Central lines of putting flues in, first drilling 1⅞-inch holes, using 95 copper and swaging the flue in to 1 11/16, and continuing back for 4 inches. By doing this it gives us a larger brace and a better circulation of water at the fire-box end. Two years and a half ago this experiment was tried on the Lake Erie & Western, a road where we could not get any more than 10,000 miles out of our flues, on account of the accumulation of mud and salty water, and we increased the mileage from 10,000 to 40,000. We have boilers on the Lake Shore road to-day making as high as 100,000 miles, both passenger and freight. A year ago last January we introduced the system of applying brick arches close against the sheet, and since we have been doing that we have engines running in districts where formerly they had to be calked at every roundhouse, and now they are making twenty-one trips without a boiler maker going into the fire-box. Somebody might make an objection about the arches going against the sheet on account of the accumulation of scale or dirt on the arch; but a brick arch is like anything else about a locomotive, it wants looking after, and when it is properly attended to at the terminal it will not give any trouble. And with our method of fitting the bricks in, at the present time we are getting as high as three months out of a set of bricks on our freight engines, and we are getting from thirty to sixty days on our passenger engines.

Mr. Lucas corroborated the foregoing statements, showing that the mileage on fifteen engines, in from twenty-nine to forty-nine months' service, all heavy power, 200 pounds pressure, had averaged from 118,000 to 241,000 miles. He stated that they had used the arch a great many years and thoroughly believed in it.

Mr. German: I go over five different roads. We have got places where it was impossible to run an engine any longer than four months and other places where it was impossible to run them any longer than twelve months. To-day we are getting two years and ten months out of them in the same places, and the water conditions are just exactly the same as they were then, but we are using brick. We are washing our boilers clean with the use of soda.

Mr. Letteri: We had a place where our flues only ran three months, and by reducing the flue we gained a little, but reducing it did not prevent the mud from getting in the boiler in the front end. The life was a trifle longer in the back end, but it started to leak in the front end. I never saw a brick arch where you could keep mud out of the boiler.

Mr. Wilson: I think there is one thing that is neglected more than anything else, and that is the boiler washing. Boiler washing has as much to do with the life of the flues as anything in the world. We have about 225 engines, and run from 115 to 125 a day. When I first went there we had considerable trouble with flue failure, and one of the first points I took up was boiler washing. I found out that the plugs of those boilers had never been removed since they came from the locomotive works, and some of the old boilers did not have half enough plugs in them. I have been putting from twelve to fifteen extra washout-plugs in those engines, and I have not had an engine failure due to leakage or falling down on the road during the last six or eight weeks.

FRIDAY MORNING SESSION.

The convention was called to order at 9.30 o'clock by the president.

Steel vs. Iron Flues.

(An abstract of this report is published on page 163.)

Mr. O'Connor: Last May we equipped twelve engines with steel and iron flues, half and half. Those engines are in service and we have not taken any of the flues out. Up to the present time I cannot see any material difference, only that the steel flue, by testing it carefully, seems to have a little advantage over the iron in hugging the sheet.

Mr. Sarver: I do not think it is the duty of any committee to recommend whether steel or iron should be used. But when you appoint a committee on a subject and ask that committee whether steel or iron is best, they have certainly got to say one thing or the other. From my experience and from the figures and from the mileage and from the service that we have gotten from steel safe ends, it would be impossible for me to come down here and advocate iron, especially when my steel has run from twenty-five to thirty-five percent more than iron in the engine. We had an engine that ran 40,000 miles with iron flues and we took it in the shop and applied steel safe ends and the engine has run 72,000 miles and she is running yet. So you see that I cannot come down here and say that iron flues are as good as steel.

Mr. Brown: We ought not to lose sight of conservatism. I do not see how this assembly can adopt or recommend what material we shall use. The railroad company which I represent covers a vast area of country. We have good-water districts and we have bad-water districts. You have heard the good results reported by our committeeman of the services steel flues have rendered his company. I presume we have members here who can give us a report of the good service iron flues have given. It is only recently that I had to throw out flues weighing 22 pounds to the flue, practically new. There ought to be a long life in store for those flues, but the defect was on account of the action of the water upon them, causing pitting. We have iron tubes in those same districts and you would not know there was any trouble with them. You can cite me as using both iron and steel. We are building twelve high-pressure boilers and there is a test being made with steel versus iron. A year from now I will have information as to the results of it. I want to remind you that it would be impertinent for this convention to recommend any material that would not be good in certain localities.

Mr. Troy: I have had a little experience with steel tubes, and I presume that in some places they will run, but not in my district. I applied a set of steel tubes in an Atlantic engine carrying 200 pounds steam pressure and after 30,000 miles I removed the tubes and I had to throw 50 percent of the bottom tubes in the scrap, they were so badly pitted.

Mr. Gray: We have quite a number of steel-body tubes and a great many safe ends, and as far as the leaking of the tube is concerned and the life of the tube in the fire-box, I have not been able to find practically any difference in my district.

Mr. Lucas: We put our first set of seamless tubes in January, 1905, and we removed them after 45 months' service, 168,000 miles. There was no pitting. Every tube went back in the boiler again. We have about eight or ten sets in service still doing business and we have found no pitted flues. We have iron tubes that are pitted badly on one of our divisions, scrapping twenty-four hundred in six months, where we only scrapped during the six months 542, on account of light weight.

Mr. Brown: We weld iron ends on, steel tubes and steel tubes on iron ends, and we have trouble in making these welds. But going back to the water conditions on the Louisville & Nashville, I have got iron tubes that have made 130,000 miles between change of tubes.

Mr. Filcher: We have used both steel and iron flues on the Big Four. We have got seven or eight different divisions where we are treating the water with lime and potash and we have never experienced any more trouble with steel than iron.

We have found as much pitting in iron as we have in steel. As far as the service is concerned, we have had better results from steel than from iron by mileage, but as far as pitting is concerned we never noticed any bad effects of the water in pitting where we had the treating plant, but where we have not had the treating plant we found trouble with both iron and steel pitting.

Mr. Letteri: I started in on the steel tube I think in 1896. We made a three-year test of them. Regarding pitting, my experience does not go so very far, but as far as our water is concerned, it is very hard lime water, and we all know that no pitting takes place in lime water. The pitting only takes place in places that have real pure water. As far as service is concerned, just as Mr. Sarver had in his report, the end that is in the sheet, when the flues are removed, is heavier at the present time than the iron flue would have been in three months' service, and the flues at the present time are not removed on account of the flues being worn out, but simply to get the mud and scale out of the boiler.

Mr. Wandberg: I find that an engine in constant service is not as apt to pit the flues as one that is taken out of service and left out of service from time to time. As far as pitting between the iron and steel is concerned, I could not say which would pit the quicker. I have seen condenser tubes badly pitted due to the proximity of an electric generator and also tubes pitted by blue vitriol in the water, but in both of these cases it was not the fault of the flue material.

In reply to a question, Messrs. Sarver and Letteri both said that they found no difference in the cleaning and the scaling of iron and steel tubes.

Mr. Cushing: When I started on this subject of steel flues we were getting 22,000 and 23,000 miles out of a set of flues. We put a test set in and instead of getting 22,000 or 23,000, we got 69,000 miles. I removed the tubes and had them cleaned and examined and I found no signs of pitting. I also had some iron flues and found no signs of pitting in them. But in the last two years, I find where the flues have been in service four or five or six years, I find pitting on both the iron and steel, but I do not attribute it to the material, I attribute it to laying the engine up for a month or six weeks at a time. I also attribute it to the flues being taken out of the boiler and put aside and left in the weather, and the rain comes on them and they rust, and that starts the pitting. I do not think it is the fault of the steel or iron, but it is the fault of the handling.

Mr. Linderman: On our passenger power with iron flues, the best we could do was 55,000 to 65,000 miles. With steel we raised our mileage from 110,000 to 148,000. We have no pitting. We find that steel tubes clean a little easier than the iron.

Mr. Johnston: I am now connected with the Santa Fe, and in the last two years we have adopted the iron tube, and we have had flues after eight months' service come out of the boiler and be thrown into the scrap pile, due to pitting. I believe that the great trouble with flues is leaving them out in the weather, and the pitting starts at that time.

Mr. Andrew Green: I think those who have not had any experience with steel tubes will get good results if they try them.

Mr. Cook: In the last eight years we have bought nothing but steel tubes. We haul the biggest tonnage in the United States for a small road. We have engines carrying 125 pounds pressure that use steel tubes. We weld them on to anything we have got. We have got any amount of old iron tubes; some of them have been welded fifteen times, and we have steel ends on them to-day. As a general thing on the Bessemer road they use nothing but steel tubes, and they buy nothing else for ends but steel.

Mr. Kelly: During the coming year I would like to have the members each make a test, putting in half-and-half in the same engine, the right side iron and the left side steel.

Mr. Lowe: As a representative of the Canadian Pacific Railroad, I will state that we are operating in the neighborhood of 1,500 locomotives. The Western lines which I represent have about 740. We are using the iron tubes, except in those cases where we are having experiments with steel tubes and other kinds. In the good-water districts, as regards renewal, we are governed by the time adopted for internal inspection. In the same districts, with the steel ends, we find no gain or loss in connection with either material. But when we come into bad-water districts it is not a question of vitality of the bead or security to the tube sheet, but rather it is a question of having to remove them for scale. We have been using the iron tube for many years before I came to your convention. We have practically found no gain or loss in bad water, and in good water any flue stays in long enough.

Mr. Lucas: In making this test, when you get your people to buy a set of iron tubes, I would like the members to keep a record of the work done on each set and the number of flues plugged when in the shop, and give us complete data of what has been done. It will be well to state whether it was a good grade of iron tube against the steel tube, or a common body grade of iron against the steel tube.

Mr. O'Neal: I have had a great deal of experience with steel tubes, and I find, after making several tests of them, that by putting in half sets of iron flues and steel, in certain districts where we applied these flues where the condition of the water was very bad, we took the flues out in about fourteen months, and we found that the steel flues were pitted so bad we could not put them back; the iron flues were not pitted at all that we could notice. Before this I had been ordering all-steel flues. I am still ordering them, and I find I get better service from the steel ends than I do from the iron ends, but I find that the steel seems to pit. It doesn't seem to have any particular place either at the bottom or top of the flue. After noticing it very closely and studying these little pits, I think there is some kind of sediment of sulphur that causes it; the action of our water has a tendency to cut through. There will be a small pit, and the flue will be all right all around for 12 or 14 inches, and still this little pit eats right through it. In the iron flue we do not notice that at all. However, I find that the steel end does better in the sheet than the iron end does, and for that reason we have adopted the iron body, welding the steel end on, and we get very good results from it.

Mr. Rapp: In regard to this proposed test, to be absolutely fair with both materials I believe it would be better, instead of putting in one material on one side and the other material on the other side, to put in alternate rows.

Mr. Elkins: I tried that scheme a few years ago and could not find any difference about the flues leaking. When I took the flues out, after eleven months, I found that the steel flues were pitted a little bit worse than the iron. That resulted after eleven months' service in bad-water districts.

Mr. Brown: In our mineral districts, where steel will not exist and iron will, these twelve boilers we are making I think will be a fine test of this. The flues on one side will be iron and on the other steel. I will give this my undivided attention for the next twelve months, and be ready to report at any time.

Mr. German: We have almost completely prevented the pitting of flues and side sheets by the use of soda ash.

The report of the committee was received with thanks, and it was voted that two more members be added to the committee and it be continued for another year.

Best Method of Applying Brick Arches.

Some roads use the plain stud screwed into side sheet to support the arch; others use the steel angle fastened to the side sheet, and a great many roads have adopted the use of the circulating tube, or, more commonly called, the arch tube.

On the Chicago & Northwestern Railway, all arch brick are mounted on arch tubes. We find it more convenient to apply arch brick on circulating tubes on account of the very short time it takes to apply; also the uniformity of the arch and the simple manner in which the arch can be removed and replaced in locomotives having boiler work to be done on arrival at terminals. A number of railroads object to the circulating tube on account, as they claim, of failures in tubes cracking and the probability of tube blowing out, causing delay and possible danger to the engine crews. In our opinion arch tubes properly applied and properly taken care of are not any more dangerous than any other tube in fire-box.

Mr. German: Putting all prejudice to one side, let us give the brick arch what it deserves. The brick arch, like everything else put in a locomotive boiler, must be taken care of. When it is properly applied and properly taken care of it is no detriment to a fire-box, and it is a protection to the flues. A year ago, on the Lake Shore road, we applied brick arches, and had arch pipes in all our engines. They took the arch pipes out because they would scale up and burst and crack before we could change them. On the Lake Shore they applied brick arches on both the narrow and wide fire-boxes. The bricks at first were laid on top of the arches in two pieces. It was a matter of impossibility for a boiler maker to go in there to do any work on the flue sheet and take those bricks down without breaking them. They were too heavy—a man could not lift them. It was a hard job to get men in the fire-boxes when they were used. Then we adopted a system of putting the brick arches in in pieces, and since we adopted that a year ago last January, instead of running the arches as we had previously, three and four trips, we are running them now as high as ninety days, and we are saving—this comes from the general office—all the way from 8 to 12 percent of coal by the use of them. I might say that we have 75 percent less boiler work to do on the flues since we put them in. We have cleaners for cleaning our arch pipes in districts where it is needed, called the Cyclone Turbine Cleaner. The arch we build at the present time is easily removed. A man can take each individual piece out and lay it down and then place it back again. We very often break two or three pieces in removing one when they are beginning to get old, but we don't destroy the whole arch. Our arches are fitted close against the sheet, with no opening, and our engines are drafted accordingly, so it will take action on the bottom flues to keep them clean. In 1907 it cost the company $43,000 to keep 592 engines in service without bricks. In 1908 542 engines were equipped with bricks, and it cost the company $11,000 to keep those engines in service. I have the statement from our superintendent of motive power that by the adoption of these bricks it saved from 8 to 12 percent of coal.

Mr. Johnston: We use the brick arch much the same as Mr. German. We leave an opening of 6 inches between the flue sheet and the arch, and we have good success. About eight years ago, up in the Northwest, we made a test of twelve engines, six of them without the arch and six of them with the arch, and the percentage in fuel saving was something enormous, the six engines with the arch being the successful engines. But we had to take care of those arches; we had to keep them perfectly clean at all times. If this is done, I assure you that there is not a road in this country but what would get the same results.

Mr. German: It is a well-known fact that the fire coming in direct contact with the bottom flues causes them to leak. If you put a brick arch in a fire-box, put it in as a combustion chamber, to stop the fire from coming in direct contact with the flues, and then you will stop 50 percent of your leakage, especially if you individually get hold of your engineers and firemen and tell them to use their feed water as they ought to.

It was voted that the subject of brick arches be carried over for another year.

Flexible vs. Rigid Stay-bolts.

The report of the committee on this topic was presented by Mr. C. J. Murray. The first point emphasized was the relative cost of applying flexible and rigid stay-bolts. It was shown that it costs practically 50 percent more to install flexible than rigid bolts, but that this difference in the first cost is more than offset by the cost of repairs while the engine is in service. With rigid stay-bolts it is usual to find from fifty to 150 broken bolts when an engine is shopped, and it is frequently necessary to shop an engine in thirty days on account of broken stay-bolts. Not only is the cost of renewing the bolts to be considered, but also the loss of the earning power of the locomotive while it is out of service. This amounts to from $600 to $700 per day. Cases were cited showing where engines equipped with flexible stay-bolts had been in service for over two years and not had a single broken stay-bolt, so that in the end the flexible stay-bolt must be considered the most economical. A full installation of flexible stay-bolts was recommended, due to the fact that where a partial installation is made, the rigid bolts adjacent to the flexible bolts are frequently found to break.

Mr. Murray outlined his method for applying flexible bolts when a partial installation is made. The zones for solid bolts are first mapped out and these bolts run in. The fire-box sheets are then held secure from the danger of pulling in when the flexible bolts are applied. As it is an easy matter to draw in the fire-box sheets from ½ to ¾ of an inch when applying flexible stay-bolts, this method has been found of great value. If it is to be a complete installation of flexible stay-bolts, a few solid bolts are put in to stay the fire-box sheets, and afterwards the holes are reamed out and flexible bolts substituted.

It was recommended that flexible stay-bolts be tested by a hammer test under air pressure when it is possible to get a pressure of from 125 to 150 pounds per square inch. The best method of applying flexible stay-bolts is the universal method used by the Tate stay-bolt people. After the fire-box is in position, drill the outside holes to the proper size for reaming and tapping, preparatory to applying sleeves. Previous to the application of the sleeves, use a brass plug with a ⅞-inch center to the plug, screwing this plug into each successive hole to tap out the fire-box sheet. Then apply the sleeve and the bolt, hammer over same, using either a pneumatic holder-on with special die, or a bar made exclusively for the holding-on of flexible stay-bolts. When the bolts are hammered over and finished, the cap is applied and the job is complete. It was suggested that wherever possible these stay-bolts should be used for crown and radial stays, as well as for staying the side sheets. A commendable feature of the flexible bolt is the ball head, which permits the fire-box sheets to expand without placing any additional strains on the bolt.

The report of the committee was received with thanks and the subject carried over for another year, the committee being instructed to give careful consideration to the 1906 report of the Master Mechanics' Association on this subject.

Standardizing of Blue Prints.

The committee simply reported progress and was continued for another year.

Senate Bill.

The committee recommended that the association take no action on this subject. This report was received with thanks and the subject dropped.

FRIDAY AFTERNOON SESSION.

Oxyacetylene Welding.

M. S. Courtney, general boiler inspector of the Great Northern Railway, St. Paul, Minn., described the process of oxyacetylene welding in use on the Great Northern Railroad. On this road patches are now welded into the side sheets of fire-boxes by the oxyacetylene process in comparatively short time with gratifying results, and thus far the work has been absolutely satisfactory, with no sign of leakage. The oxygen is generated from chloride of potash and dioxide of manganese. The acetylene generator is one which was designed by Mr. Emerson, who also developed the blow torch which is used. By means of this process fire-boxes are now cut out 50 percent faster than by the former method of cutting out rivets, stay-bolts, etc.

In welding patches in fire-box sheets, the defective part is first cut out with the torch, and the edge of the side sheet beveled to an angle of 60 degrees. The edge of the patch is also beveled to an angle of 60 degrees, and then the patch is placed in position so that the two beveled edges form a V-groove, into which the additional metal is allowed to flow during the welding process.

Much of the success of this process depends upon the kind of metal used in welding. At first, spring steel about 3/16 inch diameter was used, but this was found to be too hard. Then vanadium steel was tried and gave promise of good results, but that was finally found to be too hard after being heated to a welding heat. Finally Swedish iron was used with good results. This iron is fibrous and tough; it is also ductile, and in order to use it in welding it is unnecessary to heat the adjacent plate at a great distance either side of the joint. This is an important point, as heating an excessive area of the joint causes local expansion, which interferes with the placing of the patch.

It is now the intention to equip all of the Great Northern boiler shops with oxyacetylene welding apparatus, and to use it, not only for boiler work, but also for repairing castings and other machined parts. Up to date there are from twenty-five to thirty engines on this road which have welded patches in the fire-box, some of them as large as 30 by 36 inches, and those engines have given no trouble. In some engines which gave trouble by leakage at the longitudinal seam in the fire-box, a strip about 9½ inches wide the whole length of the seam was cut out by means of the torch and another sheet welded in, thus doing away with the riveted joint. This job, too, has proved entirely satisfactory and has given no trouble.

Mr. Courtney: All our engines have been running as high as fifteen months, and there isn't a particle of leaking in any of the side sheets that were welded. If an engine comes in with a crack 8 or 10 inches long, we take a diamond point and run it down, and in a few minutes it is welded. We could not keep the longitudinal seams in the fire-box tight. Now we just take a 9½-inch strip off and weld a new strip in there, and there is no trouble. We have found it a perfect success after three years, and our engines operate mostly in very bad water.

Mr. Brown pointed out that the metal in the weld was merely puddled iron, and he cited several instances showing that this puddled iron would break or crack when bent, showing that it was neither as ductile nor as strong as the metal being welded together.

The President: It appealed to me as a nice thing to use in place of plugs. Take a crack 2 or 3 feet long, and rip it down with a diamond point. By ripping it open ¼ of an inch the metal will not bind, and it will weld solid.

Mr. German: We have been using this process of welding cracks for the last two months. They have run engines in from the roundhouse that had six or seven cracks, one crack 20 inches long, and they were all welded. The engines are giving good service. We have not tried it on side sheets yet.

Mr. Flavin: I want to assure the convention that the welding process is the coming thing, and is going to revolutionize our business. Somebody referred to cutting out a patch. The man simply points a line about as heavy as a lead pencil. He can cut out a patch at the rate of 10 feet an hour. There is no round corner and no radius to be drawn. It doesn't make a ragged hole, but one similar to that made by a ripper following a diamond. The edges of the hole are bevelled at just about the angle you use for calking. Then the patch is sheared on the bevel shear and put into place, the stay-bolts are applied to hold the patch right, and the operator comes with the burner, just like a coppersmith, and he welds at the rate of 12 to 14 inches an hour. When he gets through the patch is homogeneous with the fire-box. I watched an operation on a locomotive with a fire-box 12 feet long. They burned out the entire section up to the flange. They don't do any lap welding, because it is not necessary. In forty hours this engine was ready for service. I waited until after the fire was put in, and you could not find the patch. I have seen it on engines sixteen months old. The welding process is here to stay, and it is going to revolutionize our entire trade.

The President: If anyone can go up to the Great Northern at any time it will be to his interest. They will show you everything, and tell you what they have done with it. It appealed to me as being the coming thing.

Mr. Rapp: The applications that torch can be put to are wonderful. I believe it is going to be a great money saver to all the railroads in the country. As far as the cutting part of it is concerned, those that have never seen it cannot realize the rapidity of the work. They cut at the rate of, I judge, 14 to 16 inches a minute ¼-inch steel. Portable plants are made which can be loaded on a dray and taken out.

Mr. Lucas: I visited the Great Northern shops and saw patches that had been in service eight and nine months, large patches, where it was necessary to wipe the soot off the box to find the location of them. We will have a burner by the time I get home. We are going to try the oxy-hydrogen burner.

The association unanimously voted to accept Mr. Courtnay's paper and extend him their thanks.

Report of Committee on Standard Tools.

The committee appointed on Wednesday to consider the report on standard tools, machinery and equipment recommended that the committee take up this report during the coming year and communicate with manufacturers of these tools, with a view to ascertaining the desirability of adopting the proposed International Master Boiler Makers' Standard for punches, dies and couplings, and also for drift pins, and the bushing or mouthpiece for pneumatic tools.

Mr. Wandberg: I do not know whether I am out of order or not, but I feel that we ought to say a few words in behalf of THE BOILER MAKER, *a very able paper that is published for the benefit of boiler makers. I feel that every master boiler maker should take an interest in this paper.*

The President: We all know that it is a very able journal, and each and every one of us should advertise it as much as possible wherever we go. I do not believe there is a better journal in this country.

Mr. Goodwin: It is the only one.

The report of the committee on resolutions, comprising acknowledgments of the hospitable manner in which the association had been received and entertained by the citizens of Louisville, the management of the Hotel Seelbach and the Supply Men's Association, together with grateful acknowledgments to the daily and technical press, special mention being made of the liberal recognition accorded by THE BOILER

MAKER and its representatives, was read and accepted.

Cincinnati was chosen as the next place of meeting, and Mr. George Wagstaff was appointed a delegate to the annual convention of the American Boiler Manufacturers' Association, to try to induce the contract boiler makers to send their foremen to the annual conventions of the International Master Boiler Makers' Association.

The election of officers resulted as follows:

President—A. E. Brown, Louisville, Ky.

Vice-President—A. N. Lucas, Milwaukee, Wis.

Second Vice-President—C. P. Patrick, New Haven, Conn.

Third Vice-President—H. L. Wratten, Racine, Wis.

Fourth Vice-President—T. W. Lowe, Winnipeg, Can.

Fifth Vice-President—G. W. Bennett, Albany, N. Y.

Secretary—Harry D. Vought, New York City.

Treasurer—Frank Gray, Bloomington, Ill.

Messrs. Sarver, Crombie and Laughridge were elected members of the executive board for the ensuing year.

The following members and guests of the association were present at the convention: G. C. Wehling, State Boiler Inspector, Rome, N. Y.; W. H. Laughridge, F. B. M., Hocking Valley R. R., Columbus, Ohio; A. N. Lucas, F. B. M., C., M. & St. P., Milwaukee, Wis.; C. R. Kurrasch, F. B. M., C., I. & S. R. R., Kankakee, Ill.; W. H. Hopp, F. B. M., C., M. & St. P., Dubuque, Iowa; F. A. Lindeman, Supervisor of Boilers, N. Y. C. Lines, W. Albany, N. Y.; C. N. Nau, F. B. M., C. I. Southern, Hammond, Ind.; Wm. Fantom, F. B. M., C. & W. I., Chicago, Ill.; Frank Berry, F. B. M., Erie, Cleveland, Ohio; C. L. Wilson, F. B. M., I. C. R. R., Memphis, Tenn.; James Bruce, F. B. M., Frisco, Kansas City, Kan.; John Greene, F. B. M., I. R. R. R., E. St. Louis, Ill.; J. H. Nash, M. M., I. C. R. R., Paducah, Ky.; F. L. Lothrop, F. B. M., Erie, Susquehanna, Pa.; Frank J. Rahrle, F. B. M., B. & O., S. W., Chillicothe, Ohio; E. P. Kavanaugh, Boiler Inspector, B. & O., Baltimore, Md.; E. W. Young, Boiler Inspector, C., M. & St. P., Dubuque, Iowa; John McKeown, F. B. M., Erie, Galion, Ohio; H. J. Wandberg, F. B. M., C., M. & St. P., Minneapolis, Minn.; J. J. Casey, F. B. M., N. Y. C. Lines, New Durham, N. J.; T. A. Jameson, Inspector, Trav. Ins. Co., Knoxville, Tenn.; C. F. Shoemaker, Boiler Inspector, P. M. R. R., Grand Rapids, Mich.; F. A. Mayer, Gen. F. B. M., Southern Ry., Washington, D. C.; J. J. Madden, F. B. M., Rock Island, Fairburg, Neb.; John Troy, F. B. M., P. M. R. R., Saginaw, Mich.; John Harthill, Asst. F. B. M., Lake Shore, Elkhart, Ind.; M. Wulfeck, F. B. M., C. & O., Covington, Ky.; L. Borneman, F. B. M., C., St. P., P. M. & O., St. Paul, Minn.; B. H. Nudyke, F. B. M., Henry Vogt Mch. Co., Louisville, Ky.; Joe Sullivan, F. B. M., N. Y. C. Lines, Buffalo, N. Y.; Alfred Cooper, F. B. M., St. J. & G. I. R. R., St. Joseph, Mo.; Chas. H. Walker, F. B. M., West Shore, Union Hill, N. J.; C. E. Elkins, F. B. M., Iron Mountain, Little Rock, Ark.; M. J. Guiry, F. B. M., G. N. R. A., St. Paul, Minn.; C. J. Baumann, F. B. M., N. Y., N. H. & H., New Haven, Conn.; J. T. Johnston, Asst. Boiler Inspector, Santa Fe, Los Angeles, Cal.; J. E. Cooke, F. B. M., B. & L. E., Greenville, Pa.; F. Gray, General Foreman, C. & A., Bloomington, Ill.; M. O'Connor, F. B. M., C. & N. W., Missouri Valley, Iowa; C. C. McCandless, F. B. M., C., R. I. & P., Horton, Kan.; T. W. Lowe, General Boiler Inspector, Canadian Pacific, Winnipeg; J. L. Fagan, General Foreman, I. & G. N. R. R., Palestine, Tex.; C. F. Petzinger, F. B. M., C. of Ga., Macon, Ga.; H. J. Rapps, F. B. M., I. C. R. R., Waterloo, Iowa; R. J. O'Neill, F. B. M., Col. Southern, Denver, Col.; L. C. Woodington, F. B. M., Southern Ry., Knoxville, Tenn.; F. J. Sullivan, F. B. M., I. C. R. R., Freeport, Ill.; Frank A. Griffin, F. B. M., Southern Rl., Spencer, N. C.; Cornelius Bader, F. B. M., N. Y. C. Lines, Detroit, Mich.; J. H. Smythe, Resident Boiler Inspector, Schenectady, N. Y.; J. A. Coxedge, F. B. M., Missouri Pacific, Hoisington, Kan.; P. J. Conrath, Pres. of Assn., Chicago, Ill.; Daniel Coughlin, F. B. M., Erie, Hornell, N. Y.; C. L. Hempel, General Boiler Inspector, Union Pacific, Omaha, Neb.; W. M. Tucker, F. B. M., I. C. R. R., Paducah, Ky.; J. Crombie, Supt. Boiler Dept., Sawyer & Massey, Hamilton, Ont.; O. E. Wallace, American Locomotive Works, Dunkirk, N. Y.; W. H. Wood, Owner W. H. Wood & Co., Media, Pa.; Harry D. Vought, Secy. Assn.; Chas. P. Patrick, Supt. Bigelow Company, New Haven, Conn.; W. J. Graham, Supt. Loco. & Mch., L. S. & M. S., Cleveland, Ohio; G. W. Doran, Asst. Supt. Boilers, L. S. & M. S., Cleveland, Ohio; H. J. Jones, F. B. M., K. C. Sou, Pittsburg, Kan.; Geo. M. Rearick, F. B. M., B. & S., Galeton, Pa.; A. M. Dustin, F. B. M., M. P., Sedalia, Mo.; T. J. Reddy, F. B. M., C. & E. I., Danville, Ill.; J. J. Ryan, F. B. M. L. & N., Covington, Ky.; W. G. Stallings, F. B. M., I. C. R. R., McComb, Miss.; Andrew Greene, F. B. M., Big Four, Beech Grove, Ind.; Geo. A. Beland, F. B. Dept., Fitz-Hugh Luther Co., Chicago, Ill.; H. L. Wratten, Supt. Boiler Dept., S. Freeman & Sons Co., Racine, Wis.; Hal Howard, F. B. M., I. C. R. R., Jackson, Tenn.; J. J. Mansfield, Chief Boiler Inspector, C. R. R. of N. J., Jersey City, N. J.; J. H. Filcer, General Foreman, Big Four, Indianapolis, Ind.; J. F. Finucana, F. B. M., Southern Pacific, Houston, Tex.; M. McAlister, F. B. M., N. Y. C. Lines, Cleveland, Ohio; J. J. Turner, F. B. M., Chicago Term Transfer, Hammond, Ind.; John B. Smith, F. B. M., P. & L. E., McKees Rocks, Pa.; B. F. Sarver, F. B. M., Penna. R. R., Ft. Wayne, Ind.; M. S. Courtney, General Boiler Inspector, Great Northern, St. Paul, Minn.; Chas. Letteri, F. B. M., Penna. R. R., Columbus, Ohio; Peter Eck, F. B. M., I. C. R. R., Mattoon, Ill.; C. J. Reynolds, F. B. M., B. & O., Pittsburg, Pa.; J. B. Tynan, F. B. M., W. & L. E., Norwalk, Ohio; C. E. Lester, F. B. M., Erie, Meadville, Pa.; E. H. Tredinnick, F. B. M., Erie, Port Jervis, N. Y.; A. Hedberg, F. B. M., N. W., Boone, Iowa; Thos. Lewis, F. B. M., L. V. R. R., Sayre, Pa.; H. Denzler, F. B. M., Penna. R. R., Indianapolis, Ind.; F. A. Batchman, F. B. M., L. S. & M. S., Elkhart, Ind.; J. F. Beck, F. B. M., G. R. & I., Grand Rapids, Mich.; Frank Silberman, F. B. M., L. E. & W., Lima, Ohio; John German, Supervisor of Boilers, L. S. & M. S., Kankakee, Ill.; E. E. Rapp, Boiler Inspector, T., St. L. & W., Frankfort, Ind.; J. C. Keefe, F. B. M., T. & O. C., Bucyrus, Ohio; F. J. Howe, F. B. M., C., B. & Q., Creston, Iowa; J. A. Doarnberger, Master B. M., N. & W. R. R., Roanoke, Va.; J. R. Cushing, F. B. M., Big Four, Bellfountaine, Ohio; Thos. R. Oliver, F. B. M., D., M. R. R., East Tawas, Mich.; M. F. Vizard, F. B. M., P. M. R. R., Ionia, Mich.; B. J. Feeny, Trav. Engineer, I. C., Paducah, Ky.; A. C. Dietrich, F. B. M., Soo Line, Minneapolis, Minn.; R. E. Howe, F. B. M., Rutland R. R., Rutland, Vt.; Wm. McLean, F. B. M., Y. & M. V., Vicksburg, Miss.; W. M. Tucker, F. B. M., I. C. R. R., Paducah, Ky.; Stephen Holt, F. B. M., L. & N. R. R., Nashville, Tenn.; R. W. Clark, F. B. M., N. C. & St. L., Nashville, Tenn.; Jas. S. Gunn, F. B. M., I. C. R. R., Louisville, Ky.; C. J. Murray, F. B. M., Erie, Meadville, Pa.; C. H. Smith, Boiler Inspector, Mexican Central, Agnauscalientes, Mexico; P. S. Morrison, C. F. B. M., Rock Island, Davenport, Iowa; S. L. Brakebill, F. B. M., L. & N. R. R., Etowah, Tenn.; Hugh Smith, F. B. M., Erie, Jersey City, N. J.; A. E. Brown, F. B. M., L. & N., Louisville, Ky.; J. L. Meyer, F. B. M., Penna. R. R., Dennison, Ohio; T. J. McKerihan, F. B. M., Penna. R. R., Altoona, Pa.; Harry Alaman, Vandalia Lines, F. B. M., Terre Haute, Ind.; Chas. Kraus, F. B. M., Big Four, Delaware, Ohio.

The following ladies were present: Mrs. D. Coughlin, Hornell, N. Y.; Mrs. C. L. Hempel, Omaha, Neb.; Miss P. Wehling, Rome, N. Y.; Mrs. W. H. Laughridge, Columbus, Ohio; Miss Alice Laughridge, Columbus, Ohio; Mrs. A. M. Lucas, Milwaukee, Wis.; Miss A. Lucas, Milwaukee, Wis.; Mrs. C. R. Kurrasch, Kankakee, Ill.; Mrs. W. H. Hopp, Dubuque, Iowa; Mrs. F. A. Lindeman, W. Albany, N. Y.; Mrs. C. N. Nau, Hammond, Ind.; Miss Murnhigm, Hammond, Ind.; Mrs. P. F. Flavin, St. Louis, Mo.; Mrs. G. N. Riley, Pittsburg, Pa.; Mrs. W. H. Armstrong, New York City; Mrs. C. R. Phillips, Cleveland, Ohio; Mrs. Wm. Fantem, Chicago, Ill.; Mrs. F. Berry, Cleveland, Ohio; Mrs. C. L. Wilson, Memphis, Tenn.; Mrs. J. Bruce, Kansas City, Kan.; Mrs. Annie C. Greene, E. St. Louis, Ill.; Mrs. J. N. Nash, Paducah, Ky.; Mrs. F. L. Lothrop, Susquehanna, Pa.; Miss Lillian M. Lothrop, Susquehanna, Pa.; Mrs. F. J. Rahrle, Chillicothe, Ohio; Mrs. E. P. Kavanaugh, Baltimore, Md.; Mrs. E. W. Young, Dubuque, Iowa; Mrs. John McKeown, Galion, Ohio; Mrs. H. J. Wandberg, Minneapolis, Minn.; Mrs. J. J. Casey, New Durham, N. J.; Mrs. T. A. Jameson, Knoxville, Tenn.; Mrs. C. F. Shoemaker, Grand Rapids, Mich.; Miss Emma Mayer, Washington, D. C.; Mrs. J. J. Madden, Fairburg, Neb.; Mrs. John Troy, Sagninaw, Mich.; Mrs. John Hart-hill, Elkhart, Ind.; Mrs. M. Wulfeck, Covington, Ky.; Mrs. L. Borneman, St. Paul, Minn.; Mrs. B. H. Nudyke, Louisville, Ky.; Mrs. J. Sullivan, Buffalo, N. Y.; Mrs. A. Cooper, St. Joseph, Mo.; Miss Mamie Walker, Union Hill, N. J.; Miss Dorothy Elkins, Little Rock, Ark.; Mrs. M. J. Cuiry, St. Paul, Minn.; Mrs. C. J. Bauman, New Haven, Conn.; Mrs. J. T. Johnson, Los Angeles, Cal.; Mrs. J. E. Cooke, Greenville, Pa.; Miss Florence Cooke, Greenville, Pa.; Mrs. F. Gray, Bloomington, Ill.; Mrs. M. O'Connor, Missouri Valley, Iowa; Mrs. T. W. Lowe, Winnepeg, Canada; Mrs. J. L. Fagan, Palestine, Tex.; Mrs. C. F. Petginger, Macon, Ga.; Mrs. J. H. Rapps, Waterloo, Iowa; Miss Sadie Rapps, Waterloo, Iowa; Miss Esther Rapps, Waterloo, Iowa; Mrs. R. J. O'Neal, Denver, Col.; Mrs. L. C. Woodington, Knoxville, Tenn.; Miss Margaret Sullivan, Freeport, Ill.; Miss Margaret Sullivan, No. 2, Freeport, Ill.; Mrs. F. A. Griffin, Spencer, N. C.; Mrs. C. Bader, Detroit, Mich.; Mrs. J. H. Smythe, Schenectady, N. Y.; Mrs. J. A. Coredge, Hoisington, Kan.; Mrs. P. J. Conrath, Chicago, Ill.; Miss N. Thien, Chicago, Ill.; Mrs. R. T. Scott, Chicago, Ill.; Mrs. R. Owen, Detroit, Mich.; Mrs. S. Holt, Nashville, Tenn.; Mrs. J. G. Gunn, Louisville, Ky.; Mrs. J. C. Murray, Meadville, Pa.; Mrs. C. H. Smith, Aguascalientes, Mexico; Mrs. J. L. Meyer, Dennison, Ohio; Miss Ina Pearl Meyer, Dennison, Ohio; Mrs. T. J. McKerihan, Altoona, Pa.; Jas. F. Dalton, Atlas Boiler Works, Louisville, Ky.

The Boiler Makers' Supply Men's Association.

As has been the case in former years, much of the success of the convention was due to the untiring efforts of the officers and members of the Supply Men's Association, who not only contributed the funds for the entertainment but personally made all the arrangements and carried out the details of a most enjoyable programme of entertainment. No one who realizes that, in order for the association to grow and prosper, it must mean something more to the members than a few days of shop talk and serious debate can fail to appreciate the efforts of the supply men in providing opportunities for the members of the association to meet and become intimately acquainted in a social way as well as in a business way.

The programme of entertainment this year was as follows: On Thursday afternoon, April 27, the members of the association visited and inspected the shops of the Louisville & Nashville Railroad Company, while a card party was held for the ladies in the red room of the Seelbach Hotel. On Tuesday evening a reception and dance was held in the Convention Hall. On Wednesday morning, automobile and carriage rides were arranged for the ladies, while in the afternoon the entire convention were the guests of the Ewald Iron Company, of Louisville, Ky., and St. Louis, Mo., for a trip on the river. The trip lasted through the afternoon and evening, and a dance was held on board the boat. Refreshments were also served. Thursday morning was set aside for visits through the shopping district of the city, and in the afternoon the ladies were given a carriage ride. Thursday evening the annual banquet and ball was held. Friday afternoon a trolley ride was arranged for the ladies to Pewee Valley, and the final function was a theatre party on Friday evening.

Among the souvenirs given away at the convention was a paper weight in the form of a rivet, which was given by the Champion Rivet Company, Cleveland, Ohio; a Brown & Sharpe wire gage, given by the Parkesburg Iron Company, Parkesburg, Pa.; and a tape measure, given by the Flannery Bolt Company, Pittsburg, Pa.

The following officers were elected by the Supply Men's Association for the ensuing year:

President, George N. Riley, National Tube Company, Pittsburg, Pa.

Vice-president, S. F. Sullivan, Ewald Iron Company, St. Louis, Mo.

Secretary-treasurer, George R. Slate, THE BOILER MAKER, New York City.

Chairman entertainment committee, Charles Shults, Worth Bros., Coatesville, Pa.

The following members of the Supply Men's Association were in attendance: P. F. Flavin, Standard Railway Equipment Company, St. Louis, Mo.; Geo. N. Riley, National Tube Company, Pittsburg, Pa.; W. H. Armstrong, Ingersoll-Rand Company, New York City; C. R. Phillips, Seamless Tube Company of America, Cleveland, Ohio; W. P. Murphy, Standard Railway Equipment Company, Chicago, Ill.; R. F. Miller, Cleveland, Ohio; J. Roger Flannery, Flannery Bolt Company, Pittsburg, Pa.; J. F. Beck, Grand Rapids, Mich.; J. C. Halliday, Bethlehem Steel Company, Chicago, Ill.; T. F. DeGarmo, Bethlehem Steel Company, Chicago, Ill.; E. S. Knisely, Bethlehem Steel Company, Chicago, Ill.; W. C. Cutler, Bethlehem Steel Company, Bethlehem, Pa.; S. F. Sullivan, Ewald Iron Company, St. Louis, Mo.; Geo. Wagstaff, American Locomotive Equipment Company, New York City; C. B. Moore, American Locomotive Equipment Company, Chicago, Ill.; Ackland Stirling, Stirling Manufacturing Company, Detroit, Mich.; A. C. Hollingshead, Flexible Bolt Company, Chicago, Ill.; J. W. Faessler, J. Faessler Manufacturing Company, Moberly, Mo.; C. F. Palmer, J. Faessler Manufacturing Company, Moberly, Mo.; Christ. Murphy, Carter Iron Works, Chicago, Ill.; Thos. Plunkett, Revere Rubber Company, Chicago, Ill.; Henry F. Gilg, Sligo Iron & Steel Company, Connellsville, Pa.; Thos. Draper, Draper Manufacturing Company, Port Huron, Mich.; W. M. Wilson, Flannery Bolt Company, Chicago, Ill.; J. H. Lord, Jos. T. Ryerson & Son, Chicago, Ill.; T. C. Best, Jos. T. Ryerson & Son, Chicago, Ill.; A. F. Ehrenkraft, Hanna Engine Works, Chicago, Ill.; J. W. Williams, Brown & Co., St. Louis, Mo.; H. C. Finley, Scully Steel & Iron Company, Chicago, Ill.; E. A. Stone, Scully Steel & Iron Company, Chicago, Ill.; F. W. Blume, Scully Steel & Iron Company, Chicago, Ill.; W. H. Dangel, Scully Steel & Iron Company, Chicago, Ill.; Chas. Carsadin, Detroit Seamless Tube Company, Chicago, Ill.; R. B. Owen, Detroit Seamless Tube Company, Detroit, Mich.; Geo. J. Thrust, Detroit Seamless Tube Company, Detroit, Mich.; R. H. Phillips, Detroit Seamless Tube Company, Detroit, Mich.; O. P. Fothergill, Cleveland Steel Tool Company, Cleveland, Ohio; Ralph Venning, Cleveland Steel Tool Company, Cleveland, Ohio; J. A. Kinkead, Parkesburg Iron Company, New York City; Chas. Humpton, Parkesburg Iron Company, Parkesburg, Pa.; L. P. Mercer, Parkesburg Iron Company, Chicago, Ill.; Geo. Thomas, Jr., Parkesburg Iron Company, Parkesburg, Pa.; H. J. Hunter, Chicago P. T. Company, Pittsburg, Pa.; John Campbell, Chicago P. T. Company, Chicago, Ill.; Thomas Aldcorn, Chicago P. T. Company, New

York City; W. E. Watson, National Tube Company, Pittsburg, Pa.; L. R. Phillips, National Tube Company, Chicago, Ill.; C. R. Mills, "Railroad Age Gazette," Pittsburg, Pa.; E. C. Cook, "Railway Journal," Chicago, Ill.; C. C. Swift, Cleveland Punch & Shear Works, Cleveland, Ohio; H. S. Nixon, Chambersburg Engineering Company, Chambersburg, Pa.; Geo. Sevey, Otis Steel Company, Cleveland, Ohio; T. L. Dodd, Worth Brothers Company, Chicago, Ill.; R. T. Scott, Independent P. T. Company, Chicago, Ill.; W. H. Connell, Jr., Hilles & Jones, Wilmington, Del.; R. B. Owen, Detroit Seamless Tubes Company, Detroit, Mich.; Geo. Slate, THE BOILER MAKER, New York City.

Standardizing of Pipe Flanges for Boilers and Templets for Drilling Same.*

BY JAMES CROMBIE.

There are two recognized standards for pipe flanges in the United States and Canada. One for pressures up to 125 pounds was adopted by a joint meeting of the American Society of Mechanical Engineers, The Master Steam Fitters' Association and the Manufacturers, and is known as the A. S. M. E. standard. The other, for pressures up to 250 pounds, was adopted at a meeting of the Manufacturers some eight years ago. I have left out the light flange list, which is only for 50 pounds pressure, and present to you the sizes adopted by the A. S. M. E. High-pressure screw flanges differ from the A. S. M. E. standard in size of flange, diameter of pitch, circle, and size of bolts, and are intended for pressures up to 250 pounds. For steam pressure, these screwed flanges have their limitations, as the United States Marine Rules will not allow a threaded joint over 5 inches diameter.

It is necessary to use some other form of joint than the screwed one. The flange may be bored out, heated and slipped on the pipe. The pipe is then flanged over, the ends of pipe flange may be drilled and the flange riveted to the pipe. Sometimes the flange is bored out large enough to make an easy fit on the pipe. The pipe is then flanged over, the ends of pipe forming the joint. The flange is thus free to move around and engage the bolt holes in any quarter.

The British standard has one diameter of flange and one diameter of bolt circle for each size of pipe. This must appeal to us, because, in drilling, only one jig would be required for each size of pipe, to take either high or low pressure. It will only be necessary to change the bushing in the jig to suit the size of drill. The flanges are increased in thickness for the higher pressures, and the bolt diameter is also increased. In each of the foregoing flange lists, the holes are pitched in multiples of four, so that the flange may be turned to any quarter.

The Lovekin universal standard, gotten out by Mr. T. D. Lovekin, chief engineer of the New York Shipbuilding Company, of Camden, N. J., is the result of experiments to determine the best design of flange for marine work. Following are extracts from Mr. Lovekin's paper on this subject:

It seems to me there has been more talk on such items as multiples of four bolts being absolutely essential to any standard, and the thought as to how this or that suggestion would affect the valve maker with his numerous patterns on hand, than as to how this whole matter was going to affect the engineer, whether at sea or on shore.

There is no doubt in my mind but that the industrial establishments throughout our whole country are suffering from leaky joints in steam pipes and spending thousands of dollars on various kinds of gaskets in order to remedy defects which are chiefly due to a lack of strength in the flanges themselves.

* Abstract of report presented before the International Master Boiler Makers' Association.

While firmly believing in standards, he says that no good standard flange list appears to be in general use at the present time for the higher pressures. Some of the best concerns in New York City to-day are ordering forged-steel flanges of the same dimensions as the standard cast iron ones in use at the present time for large power plants, and they are ordering these ponderous steel flanges for safety only. What we all want is a universal standard, but we will never have this so long as the mechanical engineers of the world adhere to the multiple of four bolts.

Continuing, he speaks of the "bulky yet weak flange list known as the mechanical engineers' standard," which, in most cases under my supervision, has proven so inefficient in the number of bolts used as to often require the placing of additional bolts between these multiples of four after the work has been erected. Personally, I do not believe that there is a shipbuilder or marine engineer in the United States who would support such a standard as is used in the general commercial work for pressures above 150 pounds. If this is correct, why then should we not all unite in one standard for the higher pressures? There is positively no good reason why we should not have that same factor of safety in our power house that we have in our ships.

Further, in my opinion, any standard flange list should have the joints or flanges equal at least to the bursting strength of the pipe itself, so that we could rest assured that in the case of water hammers and other shocks of a similar nature we had at least done our best from an engineering standpoint.

These flanges have been designed very carefully with a view of overcoming all possible objection. They are designed for a pressure of 300 pounds, the same diameter of flange, diameter of pitch circle and number of bolts, however, to be used on all pressures between 100 and 300 pounds, the intention being to use this proposed universal standard flange list as designed for pressures between 200 and 300 pounds and then to modify the size of the bolts for pressures between 100 and 200 pounds on all pipes above 4 inches, so that we would never use less than a 5/8-inch bolt within the range of sizes given. In all these designs I have kept the section where the bolt passes through, the same throughout. Knowing this section to be more in accordance with mechanical principles than the parallel section commonly employed caused me to adopt this form, and I have had numerous samples made and tested so as to prove my statements.

In all cases where expanded joints are made, I am certain that, if necessary, we can burst the pipe without in any way affecting the expanded joint when properly made. It is also absolutely impossible to have a leak between the flange and the pipe when so expanded, for I have made numerous tests wherein I have heated both the pipe and the flange red hot and then plunged the same in water and afterwards placed them under a test pressure of 5,000 pounds per square inch without any sign of leakage whatever. This will be apparent to all when it is considered that the ends of the pipes themselves form the joint, and any additional clamping effect produced by the bolts has a tendency to pull the pipe closer to the flange in direct proportion to the angle of flare, the small shoulder at the end preventing the pipe being forced out of the flange.

The advantages sought in this flange list are as follows: First, a uniform outside diameter of pipe flange for pressures between 100 and 300 pounds; second, a uniform pitch circle for bolting flanges together; third, a sufficient number of bolts to be equal in strength to the bursting pressure of the pipe; fourth, a flange section fully as strong as the bolt section, in all cases so designed that the weight of same is reduced to a minimum; fifth, to have all bolts entirely outside of the gasket, thereby preventing troublesome leakage through bolt holes, such as is often encountered; sixth, that the areas of the gaskets between flanges may be subjected to a uniform pressure per square inch in all cases by means of the number of bolts used, said total pressure on gaskets being in excess of the tendency to pull joints apart (due to the internal pressure in the pipe), without subjecting the bolts to a stress of over 5,000 pounds per square inch, under working pressure. This feature of the gasket is a very important one, and the design submitted requires the minimum amount of material that could be desired for such purpose, thus securing a great saving in the supply and renewal of these gaskets; seventh, the flange, as shown, may be used for either copper or steel pipe and can be made of steel or iron for copper pipe, when not subjected to corrosion, therefore eliminating the practice of brazing the copper pipe to the flange, which from results shown is not a necessity, but rather a source of danger. Where necessary or advisable to use brazing metal or bronze flanges, they may be of the same sectional area as the steel flanges shown, inasmuch as these steel flanges have been designed for steel pipe, and the same sections may be made of brazing metal for copper pipe, and bear practically the same relation as steel flanges for the steel pipe.

The following figures give the working stress on the bolts due to 300 pounds pressure over the entire area of pipe and gasket:

Diam. of pipe......	2 in.	4 in.	6 in.	8 in.	12 in.	14 in.	16 in.	18 in.	20 in.
Stress in bolts....	2,850	4,210	4,540	4,560	5,540	5,220	6,050	5,350	6,000

All bolts to be of good mild steel or best grade of wrought iron. Steel of 60,000 tensile strength, iron 45,000 tensile strength, have ample safety in all cases.

The foregoing flanges are for connecting the pipe line, or for connecting valve and pipe line, and cannot be attached to the boiler. Following are a few of the methods employed to form a steam outlet from the boiler. The valve may be bolted direct to shell plate on large boilers, the spigot on the valve flange engaging the hole in boiler shell. Steel pipe flanges may be riveted direct to the boiler shell. These flanges are threaded for pipe. In British marine practice, a pad is riveted to the shell of the boiler; studs to take standard size flange are screwed in between the rivets. The flanged pad is for higher pressures. A saddle is often employed and is made from steel plate.

Some years ago the Crane Company conducted a large number of destructive tests to prove for their own satisfaction the bursting point of their flanged fittings. These fittings were principally tees and ells, only one piece of pipe being tested. The test pieces averaged: Ferro steel, 33,000 pounds, and cast iron, 22,000 pounds tensile strength. Using these destructive tests as a basis, they have formulated the following rule, which, when applied to flanged fittings, can be used to determine the thickness of metal for a given pressure, or the thickness of metal being known, to determine the pressure required to burst the fitting.

Rule No. 1. Thickness of body being known, to determine the bursting point:

$$\frac{T}{D} \times S = B$$

Rule No. 2:

$$\frac{B \times D}{S} = T$$

Where T = thickness of metal,

D = inside diameter,

S = 65 percent of tensile strength up to 12 inches diameter; larger sizes use 65 percent.

B = bursting point.

For working pressure divide result by a factor of safety 4 to 8.

The saddle nozzles used in British practice are of forged steel and are cone-shaped; this allows of one diameter pitch circle for the rivets instead of an ellipse; the diameter of top flange is British standard. I might state here that this standard was gotten up by the engineering standards committee, supported by the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Naval Architects, the Iron and Steel Institute, and the Institution of Electrical Engineers.

Apart from these standards mentioned herein, many of the valve makers have standards of their own.

Method of Patching a Boiler.

The following method of bolting a patch on a boiler perhaps shows some originality. It was required to patch the bottom of a combustion chamber of a very old boiler, badly pitted on the water side. Riveting was impossible for want of space. The patch was 5 feet by 2 feet, fitted on the fire side, and the greatest difficulty to overcome was to make the bolts watertight, owing to the impossibility of driving them or getting a contact under the heads against the bad plates. Gaskets did not appeal to the repairer, and a metallic contact was aimed at. This was accomplished by making each bolt act as an ordinary miter-seated valve. They were turned a hand-workable fit (all but the last ¼ inch, which was tight) to reamered holes of steel, and case-hardened, fitted in from the water side, and hammered up with a spanner. The "seat" was sunk into the boiler plates. There were, altogether, 128 bolts in the patch.—*Scientific American.*

ASH PANS.

BY W. E. O'CONNOR.

The style of ash pan which is attached to a modern 4-6-2 passenger locomotive, as shown in the side and end views, respectively, consists of two inclined wings reaching from the outer edge of the mud-ring at the side passing over the top of the frames to meet the hoppers. The wings are bent to suit the mud-ring, also to meet the hoppers at the proper angle, as shown in the end views. Angle-iron trimmings not only adorn the wings, but act as side boards, as shown in the sectional view. Twenty-eight inches forward of the trailer wheels, the outer edge of the wings are shaped to accommodate the spring equalizer connections, which are shown in the plan view. Raised openings are provided in the wings to accommodate the trailer wheels. At the base of the mud-ring wrought-iron pipes of a suitable length are slipped over ¾-inch studs, which support the wings and provide an air space to assist combustion at the sides.

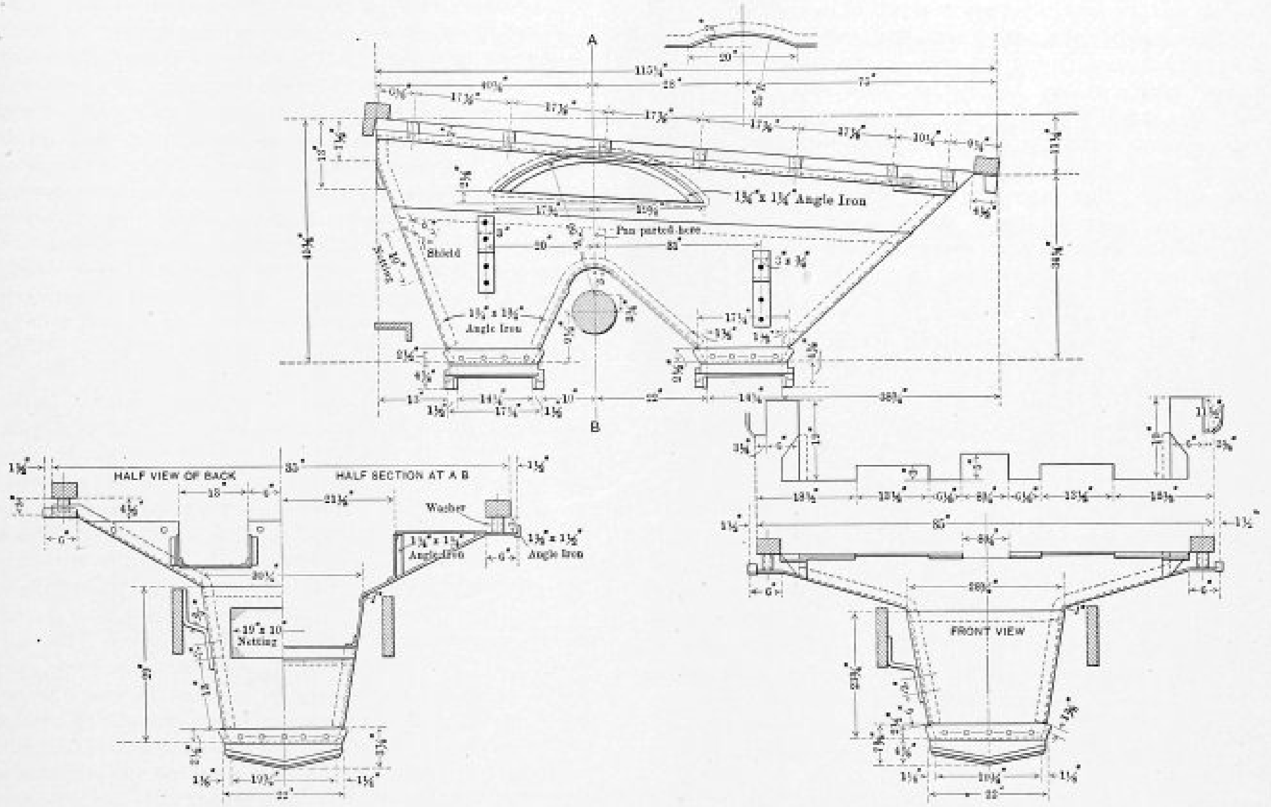
The front sheet, which is bolted to the wings, extends from the outer edge of the mud-ring at the front and slopes downward to meet the hoppers. Cut-outs, as shown in the plan view, are made to suit the castings at the base of the mud-ring. The back sheet, which is connected to the wings, is also bolted to the expansion brace plate of the boiler by six ¾-inch bolts. Openings in this plate are made to allow connecting rods to pass through to the grates.

Sheet-iron fillets to suit the openings between the brace plate and ash pan are shown in the side and end views. The hoppers are held in place by the wings, assisted by four braces attached to the engine frames, located as shown.

In place of angle iron, the end sheets are flanged in to make the joints, which means less rivets, and fewer rivets mean less labor.

The designing of an ash pan may be regarded as a secondary consideration in the make-up of a locomotive. It is made to conform to the foundation ring of the boiler, also to hang to within a limited distance of the rail, while, in most instances, the shape of the sides and ends is governed by the engine frames, machinery, etc. At present there are in general use two kinds of ash pans, namely, the solid and the hopper bottom. The solid bottom is a plain box pan with suitable openings at the ends to blow out the ashes, which is considered slow in getting the engine off the ash pit. The hopper bottom differs in this respect. Openings are provided in the bottom of each hopper to relieve the ashes by gravity, and thereby engines on reaching the ash pit are taken care of much quicker. As to the number of hoppers which a well-designed ash pan should have, no doubt this is governed, to some extent, by the length or depth of the hoppers, since the degree of opening or divergence is materially altered by the depth or length.

Of the many devices for operating the hoppers, the one shown here has given good service, since there are no details of complicated shape, no connecting rods to get out of order, simply two cast iron slides recessed to slip onto a casting, while a study of the drawing reveals the fact that the rigid casting which is bolted to the hopper serves to retain the shape of the hopper from warping, an element which, we are led to believe, may have some bearing on the wear of an ash pan.



DETAILS OF SELF-DUMPING ASH-PAN ATTACHED TO MODERN 4-6-2 PASSENGER LOCOMOTIVE.

Steel vs. Iron Flues: What Advantage and What Success in Welding Them.*

BY B. F. SARVER.

The following report from Mr. B. F. Sarver, of the Pennsylvania lines, Fort Wayne, Ind., related to steel flues:

In regard to seamless cold-drawn flue tubes, I might say that the steel is made by the open-hearth process and must be of the finest quality that can be purchased, otherwise it cannot be pierced. It is always uniform in quality, and as you do away with the welding of the flues it makes a stronger tube than the ordinary iron tube. It expands and beads perfectly, and in service the tubes hold their position in the flue sheet much better than the softer product. The steel tubes are truer in size and gage than the welded ones, and are free from the objectionable scale caused by welding. And the surface defects can more readily be found.

The surface of the steel flue is so densified that they are not so liable to be affected by pitting and corrosion, caused by the foreign substances in the water. They are very readily welded and can be installed in a boiler at a less expense than the iron tubes.

Although the steel makers do not guarantee their steel to run below .04 percent in sulphur and .03 percent in phosphorus, yet tests taken from sixteen heats made by steel makers for steel tubing showed that the sulphur did not run above .03 percent, nor the phosphorus above .017 percent.

A great many of the large railroad systems of this country are using almost exclusively the seamless cold-drawn tubes for safe ends, and they weld very readily into charcoal iron.

I cannot see why, at a less expense than iron, it would not be the most economical body tube for locomotives.

After extensive tests made by the Steam Engineering Department of the United States Navy, they recommended, some years ago, seamless cold-drawn steel tubing for the boilers of their battleships. It is also a fact with all the great navies of the world that their steam boilers are all fitted with seamless cold-drawn steel tubing.

One of the lines which I am connected with uses steel tubing for safe ends exclusively. Since the adoption of steel at this particular place they have increased their flue mileage at least 24 percent. The maintaining and calking of flues in engine house has also been reduced the same proportion, 25 percent. I have experienced no difficulty whatever in welding the steel safe ends to iron flues.

Mr. Clement Ryan, of the Union Pacific Railway, Omaha, Neb., also presented the following report:

* Abstract of report presented before the International Master Boiler Makers' Association.

"Regarding the use and value of steel, as in comparison with iron flues, beg to say that, in my opinion, iron is the best for all purposes, especially as regards pitting. We have had a great deal of experience on the Union Pacific with both iron and steel tubes, and find the steel so badly pitted after a service of from eight to twelve months as to necessitate 75 percent of the flues to be scrapped, while iron flues running over the same district and under same water conditions last for years. I would, therefore, respectfully recommend the use of iron flues with steel safe ends, as the steel safe ends in fire-boxes stand the heat better than iron. It is standard on the Union Pacific to use iron flues with steel safe ends for fire-box, and the results have been good. The welding of steel and iron flues requires a good deal of attention, as the heating of these two metals is not the same, and we have had a good deal of trouble in the past welding steel safe ends to iron flues. We would find, after the weld was made, that a point about ½ inch from the weld, the steel would be cracked, sometimes half way around the flue. To overcome this difficulty will say, that after the steel piece has been fitted to the flues and put in the fire, it should never be removed until it is ready to weld, because immediately it comes in contact with the air and is then replaced in the fire a certain percent of the welding power is destroyed."

Best Method of Staying the Front Portion of Crown Sheet, in Radial-Type Boilers, to Prevent Cracking of Flue Sheet in Top Flange.*

In the smaller and medium size radial-stayed locomotive boilers, with flue sheets from 34 inches to 38 inches wide, and having from 135 to 160 flues, which remain comparatively tight, cracks do not develop for from five to seven years. In the wide fire-box type of boiler, designed for from 180 to 210 pounds maximum pressure, containing from 300 to 400 flues, which leak almost daily, the flue sheet will crack in from one and one-half to three years.

When flues are reset, considerable tension is put on the flue sheet, the sheet sometimes stretching from 3/32 inch to 3/16 inch. When heat is applied the part in tension naturally moves toward the point of least resistance, *i. e.*, the top of flue sheet; the almost daily working of the flues, whether with sectional expander, roller, calking tool or pin, tends to accelerate the movement. As a larger number of flues are worked along the vertical center of flue sheet than along the sides, it follows that the stretching of the sheet is greatest through the center; the continued expansion resulting in a cracked margin, near the center of the upper flange, starting at a flue hole and often continuing through the root of the flange into a rivet hole. The narrower the margin above the flues, the greater will be the tendency to crack; likewise, all other conditions being equal, the deterioration of a flue sheet in a bad-water district, where flue leakage is considerable, begins much earlier than in a good-water district where leaky flues are the exception, the life of the former being from three to five years, of the latter from six to eight years.

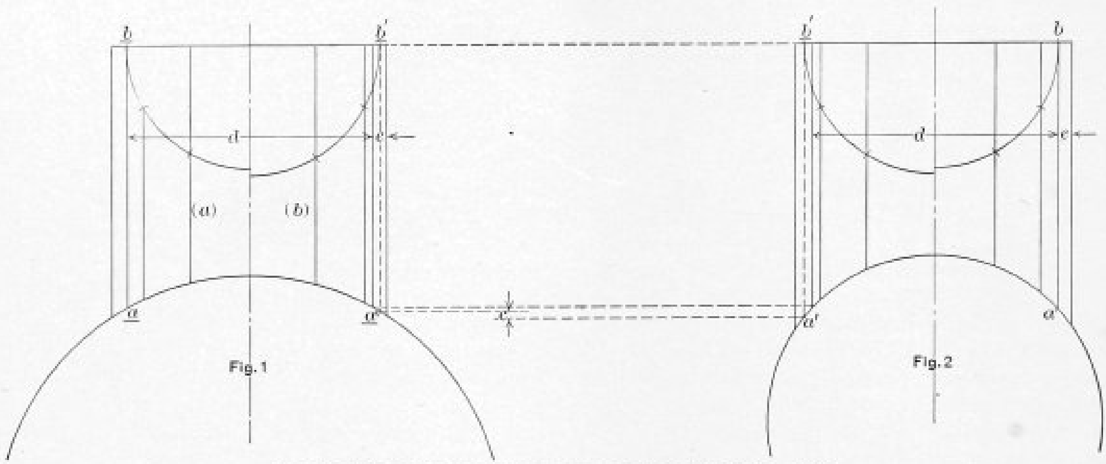
On some railroad systems this expansion is so persistent that on the removal of the flue sheets they have been found to be from ⅜ inch to 1 inch longer through the center than when applied.

The style of bracing at the front portion of the crown sheet does not seem either to add to or detract from the integrity of the flue sheet, or its ability to withstand successfully the strains put upon it.

There are three styles of bracing of about equal value, so far as the flue sheet is concerned; they are crown bars, eye bolts and tee bars, with sling stays attached. The two latter are more generally used.

On one of the large railroad systems over one hundred large-size switch engines having radial-stayed boilers, with two rows of sling stays next to flue sheet, have been in service from one to seventeen years. The flue sheets in these engines are in good condition, with an almost perfect flange, due to

* Abstract of report presented before the International Master Boiler Makers' Association.



ILLUSTRATING RIGHT AND WRONG METHODS OF LAYING OUT A DOME.

LAYING OUT A DOME.

BY H. S. JEFFERY.

It is an every-day mistake among layerouts, when laying out a dome, to draw the quadrant to the neutral diameter, as shown in Fig. 1 (*b*), instead of to the inside of the dome, as shown in Fig. 1 (*a*). This error, when laying out a dome that is to be flanged and riveted to the shell, causes the dome to be a "misfit," although the dome may be flanged strictly to the flange centers, or flange line.

The reason is very apparent by referring to Fig. 1 (*a*) and (*b*), where it will be noted that in Fig. 1 (*a*), the line *a* to *b* is not as long as the line from *a'* to *b'*, Fig. 1 (*b*). In Fig. 2 is shown the same dome used in connection with a shell considerably smaller in diameter. Here it will be noted that the line *a* to *b* is the same length as the line *a* to *b*, Fig. 1 (*a*), but due to the change in the diameter, the line from *a'* to *b'*, Fig. 2, is the distance *c* greater than the line *a'* to *b'*, Fig. 1. Since the dome will first touch the shell sheet on the inside of the dome, the quadrant should always be drawn as shown in Fig. 1 (*a*), and never as shown in Fig. 1 (*b*).

The spaces in the pattern should equal the spaces Fig. 1 (*b*), and not the spaces Fig. 1 (*a*), for should the stretchout be taken from the latter spaces it will be too short. The inside diameter *d* and the thickness *e* of the plate in both Figs. 1 and 2 are alike.

the fact that the flues seldom leak, and therefore the sheets have not been stretched by working the flues. No flue sheets have been renewed in these engines up to date.

On this system are a large number of radial-type boilers, a part of which have eye bolts and sling stays across the front end of crown sheet. The balance have the tee-bar style of bracing. Under favorable conditions the flue sheets in these engines last from five to fifteen years; where opposite conditions exist, they last from three to five years, the top flange often being bent down from 1 inch to 1¼ inches, and the sheet cracked from a number of the top flue holes to rivet holes.

In regard to their effect on the flue sheet, there was no advantage found in either style of bracing over the other.

A temporary repair for an incipient crack above the flues, is to plug the adjoining flue, the end of the flue plug to be nearly flush with the flue; the crack is then drilled out and plugged. Another method often used, is to remove the flue, inserting in its stead a pocket in the front flue sheet and a sunflower in the back flue sheet, putting a plug in the crack and hammering over on either side. In good-water districts these repairs are said to give good results, and will last for a time under the worst conditions. A more preferable way of making repairs is to apply a patch of 5/16 inch or ⅜-inch plate, plugging the necessary flue holes, scarfing the flange down to a feather edge, or removing it entirely, and riveting the patch on the fire side, completely covering the sunflowers, making the patch from 42 inches to 54 inches long, a patch of reasonable length being more successful than a short one. Patches have been also successfully applied to the water side of sheet.

Regarding the methods employed for the prevention of flue sheets cracking, the following is pertinent: On a number of railroads the sling-stay style of bracing, with an eye bolt in both crown and roof sheets, and the tee-bar arrangement, have given satisfactory results. The tee-bar bracing is to be preferred, as it is more substantial.

The bolts of these braces should be 1/32 inch greater in length, from head to shoulder, than the combined thickness of braces and web of tee bar, to allow braces to move freely. Care must be taken in applying braces to insure sufficient space for expansion between either end of brace and leaf of tee bars. It is usual to slot the holes in the braces from ¼ inch to ¾ inch at the top end, or one-half this amount at either end. In bad-water districts it is preferable to slot the upper holes only, on account of the liability of the lower ones filling with scale, and causing the braces, in time, to become immovable.

In applying the eye-bolt arrangement of sling stays, the following facts are worthy of note: The eye bolts for crown sheet where a button-head bolt is preferred are made with an enlarged neck or shank, the button-head bolts being tapped into them. Where a smaller head is required, the eye bolts may be tapped into the crown and hammered over. The eye bolts in roof sheet are either hammered over or nutted, a copper gasket being placed under the nut. When flat braces are used, it is customary to slot the hole in upper eye bolt. With the double-jawed brace with forged eye, slotting is unnecessary, as the oval-shaped holes furnish ample room for expansion.

Regarding the number of sling stays, no standard is followed; from two to five rows are used. The same is true of tee bars, some roads using one, and others two.

For further prevention of cracks, we would recommend that no unnecessary work be done on flues, as it tends to destroy, not only the flues, but also the flue sheet, also that upper flue holes be located not less than 4 inches from center of hole to inside of flange, leaving out eight or ten of the top flue holes.

A member of the committee suggests that a 2¾ inches by 2 inches by 7/16-inch angle from 48 inches to 54 inches long be riveted above the flues to stiffen the margin, the 2-inch leaf to be uppermost and extending toward the front, the upper flue holes to be spaced 4 inches from inside of flange; with a reasonable radius at the root of flange. This would bring the top of angle opposite the point of tangention made by the face of sheet and the corner of flange, eliminating trouble on account of scale formation by the avoidance of a gap between flue sheet and angle.

Letters on the subject, written by members of the association, seemed to show that cracked flanges at the top of the flue sheet could be largely overcome by the use of some form of sling bracing in place of the first few rows of radial stays.

Weight of Steam Discharged per Hour by Safety Valves.

BY H. O. KEFERSTEIN.

The following table shows the weight of steam in pounds discharged per hour through different-sized safety valves at various pressures, ranging from 100 to 250 pounds gage. The weights in this table are figured for a valve lift of 1/10 inch. If the lift varies, the values should be multiplied by various factors as follows:

For a lift of 1/16 by .625
" " " " 5/64 " .78125
" " " " 3/32 " .9375
" " " " 7/64 " 1.09375
" " " " ⅛ " 1.25

The formula used in computing the weights was

$$W_1 = \frac{W \times P_1 \times A}{P}$$

derived from Napier's formula for $A = 1$ square inch, and $P = 114.7$ pounds (absolute pressure).

Where $A =$ discharge area.

Napier's formula gives $P = 5,899$ pounds. It is found, however, after practical tests that $P = 5,176$ pounds as an average, and here P is taken equal to 5,000 pounds for safety.

$W_1 =$ weight of steam discharged,
$P_1 =$ absolute pressure,
$A =$ discharge area, or $\pi \times D \times L \times .707 = .22\,D$ square inch.

Where $D =$ valve diameter,
$L =$ lift of valve (in this case 1/10 inch).

Napier's formula is:

$W = 51.4285 \times P \times A$ pounds per hour.

TABLE GIVING APPROXIMATE WEIGHTS OF STEAM DISCHARGED PER HOUR BY SAFETY VALVES.

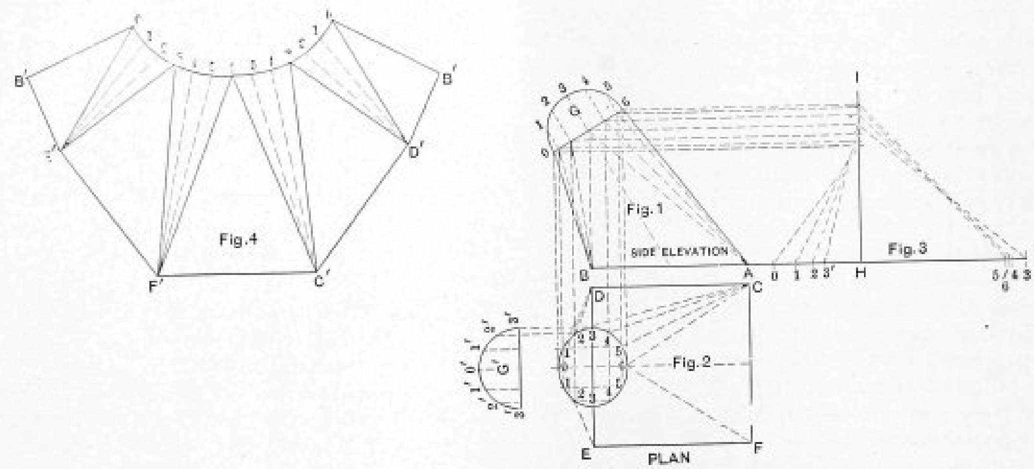
		Pounds Per Square Inch.					
Gage pressure		100	125	150	175	200	250
Absolute pressure		115	140	165	190	215	265
Diameter of Safety Valve. D.	Discharge Area Sq. Inch. A.	Weight Discharged Per Hour.					
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1"	0.22	1,100	1,338	1,577	1,673	1,912	2,530
1½"	0.33	1,650	2,008	2,366	2,510	2,869	3,795
2"	0.44	2,200	2,677	3,154	3,346	3,826	5,060
2½"	0.55	2,750	3,346	3 944	4,182	4,782	6,325
3"	0.66	3,300	4,016	4,732	5,019	5,738	7,590
3½"	0.77	3,850	4,685	5,521	5 856	6,695	8,855
4"	0.88	4,400	5,354	6,310	6,692	7,652	10,120
4½"	0.99	4,950	6,024	7,098	7,529	8,608	11,385
5"	1.10	5,500	6,693	7,887	8,366	9,564	12,650
6"	1.32	6,600	8,032	9,464	10,038	11,077	15,180
7"	1.54	7,700	9,370	11,042	11,712	13 390	17,710
8"	1.76	8,800	10,709	12,620	13,385	15,304	20,240
9"	1.98	9,900	12,048	14,197	15,058	17,214	22,770
10"	2.20	11,000	13,387	15,774	16,731	19,129	25,300

[Editor's Note:—In view of the fact that recent experiments by Mr. Philip G. Darling have shown that the lifts of various types of valves of the same size at equal pressures vary by as much as 300 percent, the lift of the valve should be determined in every case, and the weight of steam discharged as given in the table modified by the factors which Mr. Keferstein gives for different valve lifts.]

Layout of a Transition Piece from a Square to a Round Section at an Angle.

BY A. E. CLEMENTS.

First draw the side elevation, Fig. 1, then draw the semicircle *G*, which is a half profile of the round end, and divide it into a number of equal spaces, in this case six, and number from 0 to 6, as shown. Then draw the square, Fig. 2, which is a plan of the square end. Then draw the semi-circle *G'* and divide it into the same number of spaces as semi-circle *G*, numbering to correspond. By projecting the points on line 0-6 of the elevation to the plan and intersecting them by projectors from semi-circle *G'* you can draw the elliptic figure, which is a plan of the round end.



PLAN, ELEVATION AND DEVELOPMENT OF TRANSITION PIECE.

The plan and elevation are now complete. To lay out the pattern by triangulation, proceed as follows: Connect the points 0-1-2-3 of plan with the corner *D* of the square, and 3-4-5-6 with corner *C*. You are now ready to construct the diagram of triangles, Fig. 3. To one side of the elevation draw the vertical line *H I*; project to this line the vertical heights of points on line 0-6 of elevation. From *H* on a horizontal line, set off the distances 0 to *D*, 1 to *D*, etc., and 3 to *C*, 4 to *C*, etc., as found in the plan, and connect them with points of corresponding numbers on *H I*, as shown in Fig. 3. You are now ready to lay out the pattern, Fig. 4.

First draw the horizontal line *F' C'* equal in length to one side of the square. With 6-6 of Fig. 3 as a radius, and *F'* and *C'* as centers, strike arcs the intersection of which is point 6 of the pattern. With 5-5 of Fig. 3 as a radius, and the same centers, strike arcs which intersect with arcs struck from point 6 as a center and 5-6 of the elevation as a radius. Continue thus until point 3 is reached, then with a radius equal to one side of the square and *F'* and *C'* as centers strike arcs which intersect with arcs struck from point 3 as center with 3-3' of Fig. 3 as a radius. Proceed as before, with *E' D'* as centers. Continue until point 0 is reached. With *E'* and *D'* as centers, and one half the side of the square, Fig. 2, as a radius, strike an arc which intersects an arc struck from 0 as a center with 0-*B* of the elevation as a radius. Connect the points of the pattern as shown. Care must be taken not to change the dividers each time for the spaces on the round end, as the spaces are uneven in the plan and must be taken from the profile *G*.

Best Methods of Applying Flues; Best Method of Caring for Flues while Engine is on Road and at Terminals and Best Tools for Same.*

Instead of considering the numerous operations entailed in the removal and replacement of a flue, together with the various methods of terminal treatment for its maintenance, as has been the custom heretofore, we hope to confine ourselves to the consideration of the bead at the fire-box end,

Our study is being directed to the bead, because it seems to us full of interest and of importance, particularly so on account of the endurance of the material of which it is formed, the effect of the working under different tools, together with the result of the range of temperatures. The question has frequently been discussed to ascertain a reason for the existence of the bead. One school ascribes to it a certain amount of strengthening and otherwise bracing of the fire-box flue sheets, together with what is obtained by perfecting a more substantial joint; while another following claims that the bead is a necessity, for the reason that it prevents that portion of the flue projecting through the sheet from burning off. We are scarcely ready to challenge the latter theory, although it seems almost a paradox. To say that the bead is turned over on the end of the flue to prevent it from burning off would seem to be more correctly argued if it were said that the stock of material is turned over to be burnt off by the impinging flames, thus protecting the material and underlying joint it covers.

While we have not been able to secure a decided balance of opinion for either of those theories, there is still another idea, and not without its champions, that the bead does not essentially maintain the initial relation of the front and back sheets. It is not disputed that a beaded flue is stronger in tension than if the bead were left off, but still it would seem difficult to explain the existence of the bead on the score of increased stability when we pause for a moment and consider that while we are putting the bead on the fire-box end the rolling process concludes the operation in the front end. Admitting the fact that the back flue sheet is subjected to decidedly severer conditions than the forward sheet on account of the extreme variations in temperature, we must remember that the front flue

* Abstract of report presented before the International Master Boiler Makers' Association.

sheet is carrying equally the same amount of pressure per square inch as the sheet in the fire-box, still the ends in the front flue sheet are simply rolled. We might, therefore, reasonably assume that the bead is of but little value in supporting and protecting the sheet against sagging and bulging.

This brings us to the consideration of the endurance of the bead. While it is true that the bead is gradually wasting away by reason of the inpingement of the heat from the fire-box gases, it is also true that not only are particular forms of tools responsible for certain developments, but quite an equal amount can be attributed to the manner of their manipulation. We refer to the bead wasting away because its vitality is gradually decreasing. It may possibly appear under certain conditions that the bead is growing larger, but the stock is being drawn from the body of the flue. It might be well to here touch upon the difference between the effect of the roller and the prosser, the difference in the effect of the prosser with and without the boss, also the effect of the beading tool. A number of experiments seem to indicate that while there is possibly a little difference in the ultimate life of a flue when rolled as compared with one prossered, it is found that the roller has the decided effect of drawing the bead from the sheet, making it necessary that the stock in the bead be again closed down, by hand or otherwise, to again lay it up to the sheet. The tendency of the flue to draw is not entirely absent under the prosser, but less pronounced. It is also a fact, we believe, that a prosser, at least those made with the boss, can only be used for a certain period during the life of the flue. This is not true of the roller nor of the prosser where the boss has been left off. Where the bead is decreasing in size, judgment must be exercised in the use of the beading tool to prevent guttering of the flue sheet. It also requires judgment to decide just how long this latter tool can be used before it has to be given up entirely for the roller. This, of course, obtains during the latter portion of the life of the flue. It is quite possible about this period in the life of a flue to sacrifice flue sheets for flue beads on account of the manner the flues are worked and maintained, and this critical point would seem to be after about one-half the vitality of the bead had been consumed. At this period the bead has become weakened by excessive working, and perhaps has shown indications of cracking and otherwise deteriorating. As a result of a number of carefully concluded experiments, it has not been definitely shown that in the end the roller is detrimental, and therefore expensive. Referring to the sectional prosser with and without the boss, probably twenty years ago it was the idea that the boss was essential, and that as one of its functions it helped to stay the flue sheet, together with perfecting the joint on the water side, but if this was a necessity with boilers carrying 120 to 140 pounds pressure, the theory falls flat when it is asserted, and even proven conclusively, that the prosser with the boss left off is being used exclusively in boilers carrying 200 pounds pressure and upward.

Having some doubt as to the real value of the above theories, your committee has made several laboratory experiments with a view of ascertaining the holding power of different types of settings of flues, with and without beads, as well as with and without ferrules, rolled and prossered, also to determine practically the possibility of using unbeaded flues in locomotive service. Such tests have been carried along uniformly for the past fifteen months on several 100-ton consolidation freight locomotives carrying a working pressure of 200 pounds. The particular engines in question are equipped with 258 2¼-inch flues 16 feet 6 inches long. The flues were placed flush with the fire-box side of the flue sheet, making no attempt whatever to bead them. These experiments were simplified by making them on locomotives equipped with the so-called re-enforcing sheet. Nothing is claimed for the re-enforcing flue sheet in these particular experiments in the way of increasing the endurance of the bead, but by construction it permitted the flues to be so carried as to prevent any possibility of the flues pulling through the fire-box flue sheet. In among these 258 flues, fifteen flues were put in with beads, locating them regularly throughout the lower central portion of the set. While it can be said that the reports show that all of the flues required a certain amount of attention, it is also true that the number of times the unbeaded flues were worked upon, as compared with the beaded flues, is as 1 to 2.3. Encouraged by these experiments, and being able to continue in service engines with the beads left off, other engines have been fitted up in like manner, and the outcome has been that the fifteen beaded flues in the experiment above referred to gradually broke down by deterioration, but not until they had given some eight months' service; on the other hand, the unbeaded flues are still holding very satisfactorily, and have been in service some fourteen months. Upon close investigation it was found that the unbeaded flues were about normal. From the above we might conclude that the bead has no particular value towards preventing the flue from burning off; on the contrary, the beads have apparently picked up heat, and possibly in proportion to the size of the gradually increasing stock in the bead, aggravated by the thickness of the flue sheet, as well as any deposit of scale and mud, and have burned off, as might be expected. It might also be interesting to mention that while the unbeaded flues were flush with the flue sheet, they have, by reason of the rolling process, been drawn to possibly as much as 1/16 inch beyond the fire side of the flue sheet.

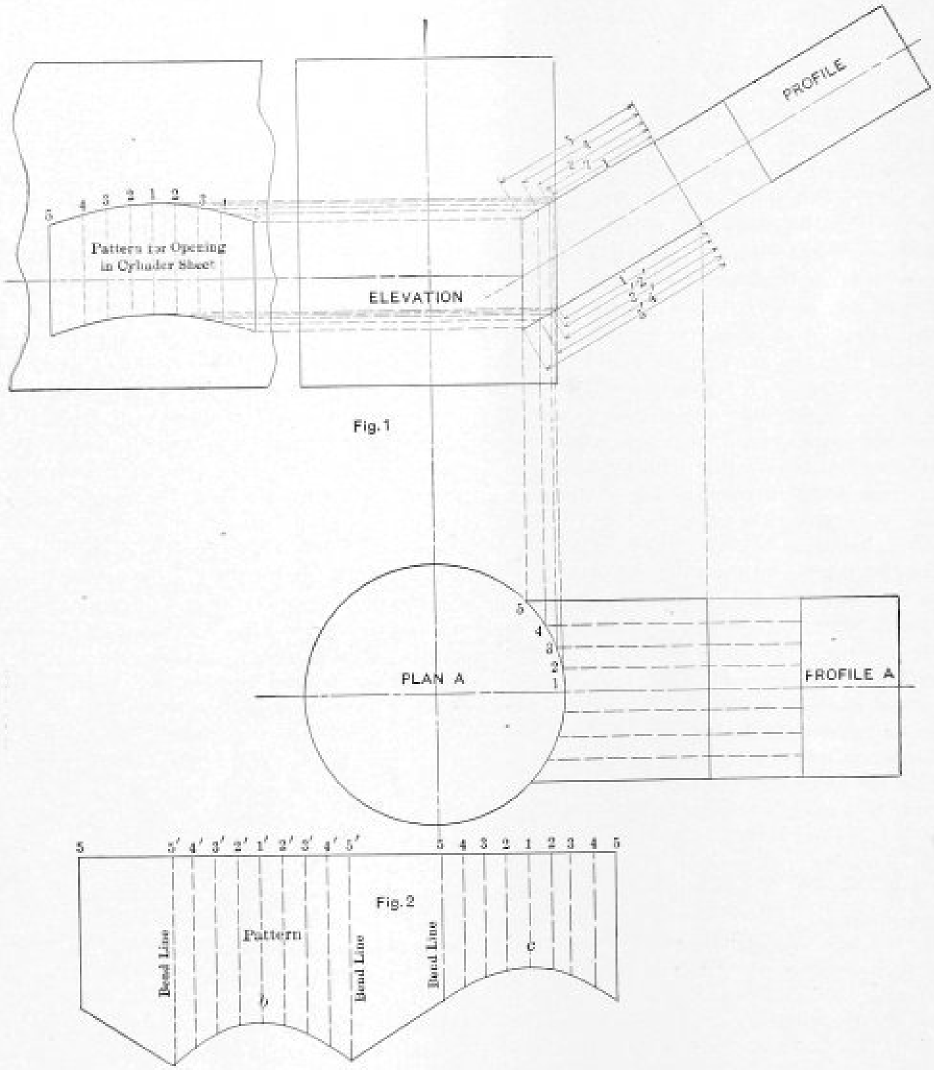
Probably in many localities throughout the country the bead determines the life of the flue, except where the water changes the conditions. It is generally known that working iron or steel, as the case may be, will harden and toughen the material, destroying its ductility, and hence under the present method of working the bead, however it is done, is from its initial application to its removal undergoing constant and severe punishment. The constant vibration of the flue undoubtedly sets up a movement in the flue sheet, resulting in not only drawing the bead and otherwise disturbing the original joint, but must also force the flue inwardly, and this theory is ventured because it is not uncommon to find the copper ferrules thinned out to twice their original length and driven inwardly. As this movement continues, the bead is gradually drawn from the sheet, increasing its exposure and decreasing its resistance to the impinging flames. In order to overcome this, the bead must necessarily be subjected to constant working and rebeading. This work produces incipient cracks in the bead, which occur as the material is gradually weakened by crystallization, and we might reasonably infer that as the material is alternately opened and closed, a certain amount of impurities find their way into the bead, all of which has been pretty well determined, resulting in breaking them down and otherwise destroying them after obtaining remarkably low mileage. The bead in its present condition is certainly a victim of circumstances, and mainly an account of the little protection it receives from the water. There is no disputing the fact that the circulation of water, however imperfect, affords some protection, but it is also true that a poor conduction of heat adds an incalculable amount towards the deterioration of the flue bead, together with the many disadvantages by reason of treatment and limitations in construction.

An act is now before the Legislature of the State of Wyoming to establish a State Board for the inspection of steam boilers and for the examination and licensing of engineers. The bill provides for an annual inspection of boilers and a hydrostatic test in excess of the working pressure.

LAYOUT OF A RECTANGULAR PIPE INTERSECTING A CYLINDER OBLIQUELY.

BY C. B. LINSTROM.

It is frequently required of the layerout to develop cylinder and irregular pipe connections, as shown in the accompanying drawings. This form of construction is generally found in hot-air heating, and it is also found in brewery-pipe work used as conveyers to the tanks or vats. The development of this problem can very readily be determined by projection drawing.



LAYOUT OF OBLIQUE INTERSECTION.

CONSTRUCTION.

First draw the elevation, plan and profiles to the required dimensions and construct the respective views, as shown in the drawing. Divide the profiles in the plan view into any number of equal spaces, in this case eight; extend these points of division parallel to the center line *A-A* until they intersect the large cylinder, as shown at the respective points numbered 1, 2, 3, 4 and 5.

The next procedure is to project these points to the side elevation and at right angles to the line *A-A* until they intersect the upper and lower portions of the rectangular pipe. Number these points 1, 2, 3, 4 and 5 for the upper portion, and 1, 2', 3', 4' and 5' for the lower; these lines are the required lines, or the true length of lines to be used in developing the pattern.

TO LAY OUT THE PATTERN.

Draw the horizontal line 5-5 equal in length to the distance around the profile, and then divide this stretchout line into four divisions, making the distances 5' to 5' and 5 to 5 equal in length to the widest portion of the profile, and the distances 5 to 5', respectively, equal to the narrow portion. In this case the seam line is located on the line 5-5. However, this is immaterial, and it can be located at the discretion of the layerout; the best practice would be to locate the seam on either the line 1'-*b* or 1-*c*, as this will aid the work for the mechanic who rivets up the piece to do his work more handily.

After the stretchout has been determined and divided into the respective divisions, as shown, divide the distances 5' to 5' and 5 to 5 into the same number of equal spaces as there are in the profile plan view; through these points and at right angles to the line 5-5 draw lines of an indefinite length. The next procedure is to determine the camber line for the connection. This is obtained in the usual manner, the true length of lines having previously been pointed out and determined; hence the method of transferring these respective distances will not necessitate an explanation. After the camber line has been determined, add for laps to complete the pattern.

DEVELOPMENT FOR OPENING IN CYLINDER SHEET.

First lay out the cylinder sheet equal in length to the circumference around the cylinder, then locate the center lines for the opening. The spaces for the development of the hole are taken from the circle in the plan view and are located on both sides of the center line, as shown from 1 to 5, inclusive. The width of the opening is obtained from the elevation, and these respective points are shown projected to the cylinder sheet.

DRILLING OUT A RIVET.

BY G. S. M'CURRY.

About eighteen years ago I was working in the Fort Wayne shops at Allegheny, Pa. One evening, just before quitting time, the foreman came to me and asked me if I would work that night, as he had a little job on hand. I was the youngest boiler maker in the shop at that time. The foreman had been to the rest of the boiler makers and told them what the job was, and they said it could not be done without taking the frame off the engine, so they refused to work. I told him that I thought it could not be done. "Well," he says, "come over to the roundhouse and look at it." So he and I went over and looked at it. "Well," I said to the foreman, "I don't feel like taking hold of that job."

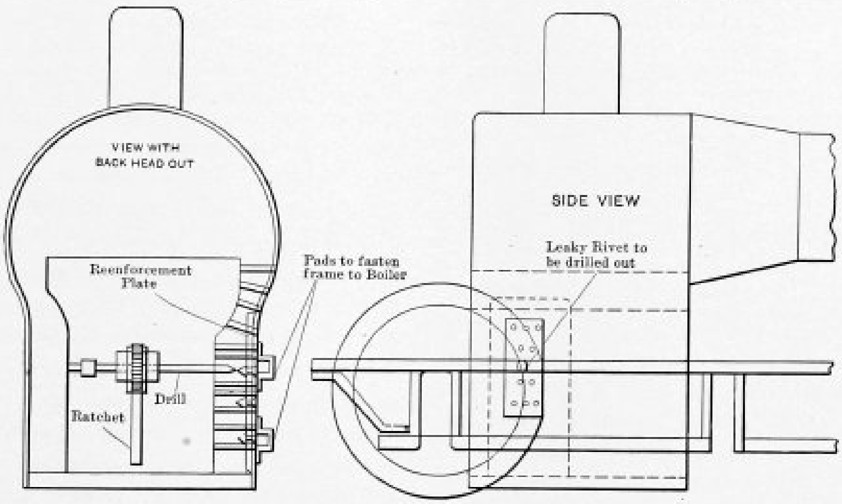
While the men were standing there the master mechanic came, and the foreman told him that repairs couldn't be made without taking off the frame of the engine. "Well," he said to the foreman, "don't cross a bridge before you get to it; you can fix that all right, and it has to be fixed to-night; for I want that engine to take a fast train out to-morrow morning." So he said to me, "Do you think you can fix it?" I told him I would try it, and now I will explain what it was.

On the side of the boiler on the inside in the water space they had a reinforcement plate riveted on to the outside plate to screw the stud in to hold the pads that held the frames to the boiler. The rivets in the reinforcement plate were countersunk on the outside with a steeple head on the inside. It was the head of one of these rivets that had broken off on the outside, right off the frame and the pad, as shown by the sketch. The water was running down in a stream, so I had to do some hard thinking before finding out how to fix it.

The foreman gave me a helper, and we went to work to drill the rivet out from the inside of the fire-box. I measured the rivets from the outside and from different points; then I went inside of the fire-box and measured; then I drilled a 11/16-inch hole in the side sheet of the fire-box, so that the hole was fairly in front of the rivet head. The next thing was to keep the point of the drill on the point of that rivet head, so we took the washout plug out of the back head, then we set a candle in on the mud-ring to give us some light, then we tried it. We put the drill in, then tightened it up. It slipped off the rivet head the first pull of the ratchet, so we tried it again and again, but it was no use; the helper threw the tools aside and said: "Let's go home, it's no use of monkeying this way." Well, we lighted our pipes and sat down to think about it.

After thinking about it for a while I got a small, long gouge, 3/8 inch diameter, and I nicked the point of the rivet head. I could not get sideways enough to gouge any off, so I just nicked it. Then we tried the drill. We would keep the drill to one side of the hole and give a few turns, then we would move it to the other side of the hole; so we kept on that way till we had the point of the rivet cut off. Then we took a long center punch and centered a hole in top of the rivet head. Then we tried the drill. We drilled for a little while. Then it ran off. Then we set the drill slanting over the other way as much as the hole in fire-box would allow, and that wasn't very much; so we drilled till it ran off on that side. Now we had the top of the rivet head level again, so I took the center punch and centered the rivet head again. Then we commenced to drill. Then the thought came to me: "What if we only drilled half of the rivet out and then had a double hole?"

That would be worse and more of it. We would have to take the frame off to fix it, sure. I was up against it hard, and felt like dropping the job, but we drilled some more. We had to take the drill out of the hole to see how it was going, for we could not see anything with the drill in the hole. Finally, we drilled through. We took the drill out and looked, and found that we drilled right through the center of the rivet!



LOCATION OF THE RIVET AND METHOD OF DRILLING.

Then the helper threw his cap up against the top of the fire-box and shouted, "Three cheers for Mc!" Well, that was agreat relief. The rest was easy. I tapped the hole out for a 1-inch stay-bolt, put some red lead on the stay-bolt, and screwed it in steam-tight. I screwed it in against the frame, then riveted over the fire-box side; by that time it was 2 o'clock in the morning. So while the roundhouse-man filled the boiler with water and fired it up we took a sleep. He told us when he had it fixed up, so we looked, and it wasn't leaking a drop, so I and my helper got eleven hours for the night. I got 25 cents per hour, my helper 14 cents per hour. So the job cost $4.29. What would it have cost to take the frame off that engine and put it back again?

Obituary.

Jasper R. Rand, vice-president and director of the Ingersoll-Rand Company, died of pneumonia in Salt Lake City on March 30. Formerly he was president of the Imperial Engine Company, and of the Rand Drill Company.

The Boiler Maker

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Prize Articles.

We extend our heartiest congratulations to the prize winners in our recent boiler-maker repair job contest. The first prize was awarded to Mr. Thomas F. Seem, Elmira, N. Y., for an article describing a method of patching a flue sheet in a locomotive boiler. The second prize was awarded to Mr. William Shoemaker, South Chicago, Ill., for an article describing a method of replacing the furnaces of marine boilers under unusual difficulties. Both of these articles are published elsewhere in this issue, and the remaining articles submitted in the contest will be published in subsequent issues.

The Boiler Makers' Association.

The third annual convention of the International Master Boiler Makers' Asociation, recently held in Louisville, Ky., marks the end of another successful year in the history of this important organization. The convention itself was a huge success, and reflects great credit on the officers of the association. It becomes more and more evident, however, as the work of the association advances, that the success of the organization is not measured simply by the success of the annual convention. The association has already attained a place of prominence in the mechanical world, and has given sufficient evidence of its resourcefulness and ability to produce results to make it respected by railroad men and manufacturers all over the country.

There is almost invariably a tendency in the early life of any organization to crowd the whole year's work into the few days on which the annual convention is held. This is obviously the wrong method of procedure, and we are glad to note that the Boiler Makers' Association is drawing away from this tendency rapidly. There can be great improvement, however, in the individual work done by the members of the association during the year. For instance, at the opening of the Louisville convention the secretary reported only seven new memberships during the year, while the loss by delinquents and resignation exceeded this number. To the outsider stagnation of this sort signifies death; that it was not so in this case was evidenced by the enthusiasm aroused during the convention in the addition of thirty-four new members to the association. Each individual member of the association should bear this in mind during the coming months, and endeavor to do as much toward increasing the membership before the convention as he is sure to do at the convention.

Almost to a man every prominent railroad official who has had the privilege of attending one of the boiler makers' conventions has emphatically expressed his approval of the association and its work, and promised to send every foreman boiler maker connected with his road to the convention on the following year. It is to be hoped that during the coming year the same interest will be aroused among the contract boiler manufacturers. An attempt to arouse their interest and support is to be made by sending a delegate of the Master Boiler Makers' Association to the annual convention of the American Boiler Manufacturers' Association, for the express purpose of urging the manufacturers to use their influence in urging their foremen to attend the convention. With all these evidences of activity it is to be hoped that during the coming year a large increase in membership will result.

The need for careful and painstaking work on the part of individual members of committees which have in hand the various topics for discussion at the annual conventions is more than ever apparent. Each committee should embody in its report not only the personal opinions and experiences of the individual members, but the sum and substance of every bit of information which they can obtain from any source whatever bearing upon the subject at hand. Such information and data are not easy to collect, but it is only by such hard and painstaking work that committee reports of value can be obtained. Evidences of work of this sort were plentiful at the recent convention, and some of the reports reflected great credit upon the committees which had them in charge.

There is another point in connection with the presenting of reports which has frequently been emphasized by the able secretary of the association, and this is the need of preparing reports at a sufficiently early date, so that they can be printed and distributed to the members of the association in advance of the convention, in order to give the members an opportunity to study the reports and come to the meeting prepared to discuss them intelligently and to the point. At the recent convention some of the papers which had been most carefully prepared did not receive the careful attention in the convention which they deserved, simply because the members had not had an opportunity to give them careful consideration. These are matters which have been continually emphasized by the secretary and other officers of the association, and are matters which we are sure will receive more careful attention from the individual members in the future.

American Boiler Manufacturers' Association.

The American Boiler Manufacturers' Association was organized at Pittsburg, April 16, 1889. The constitution adopted on that day gives as its objects the following:

1. "To establish such standards for materials and workmanship as will insure uniform excellence of construction of all American boilers, and thus secure safety to the lives and property of all communities where boilers are used, and to procure the passage of laws making the manufacture, sale or use of inferior materials criminal offenses.

2. "To concert such measures, and take such action, as shall be for the interest and advantage of its members especially.

3. "To procure and furnish to its members statistics of the trade, domestic and foreign."

The following committees were at once appointed:

On materials and tests, on rules for riveting and calking, on manheads and manholes, on bracing, stays and tube spacing, on attachment of valves and fittings, on safety valves and horsepower, on uniformity in State inspection laws.

The committee on materials and tests in 1889 and 1890 reported specifications for materials and methods of testing, which were adopted unanimously and remained the standard for eight years. In 1891 it was united with the committee on manheads and manholes, and that on riveting and calking. The joint committees made arrangements for tests of full-sized specimen shells in 1892; a disastrous fire compelled postponement to 1893, when seven such drums were tested to destruction at Chicago; analysis and discussion of these in 1895; in 1897 was instructed to prepare uniform American specifications, which were adopted in 1898; has since had charge of reform and improvement of steamboat inspection laws. Has made eighteen important reports. Is now known as committee on uniform specifications.

Committees on riveting and calking and on manheads and manholes made important reports in 1889 and 1891, and were then united with committee on materials and tests. (See above.)

Committee on safety valves and horsepower reported in 1889, 1890, 1891 and 1892, and was then merged with materials and tests.

Committee on bracing, stays, tube spacing, etc. Report in 1889.

Committee on topical questions, in its annual reports, led the discussion on leading practical questions and drew forth notable papers, such as "Driftpin," "Quality and Manufacture of Tubes," "Oil and Natural Gas as Boiler Fuels," "Western River Boilers," "Boilers and Boiler Makers," "General Shop Practice," "Acushnet Boiler Explosion," "Drilling and Punching Tests," "Annealing and Rivet Furnaces," "Boilers as a Factor in Naval Warfare," "Rupture of a Scotch Boiler under Hydrostatic Test," "Vanadium Steel," "The Two-Test Sections," "State Inspection Laws," "Crucible, Acid and Basic Steel," "Boilers for Cotton Compresses," "Hollow Stay-bolts," "Smokeless Combustion," etc., etc. These were largely used by the committee in preparing the uniform American specifications.

The committee on uniformity in State inspection laws made seven annual reports, led determined and persistent attempts in four States to pass such laws, but was finally compelled to recommend an educational campaign which, since 1898, has been carried on by the committee on uniform specifications. From Hartley's report (1908) it appears that out of forty-six States only five have inspection laws and eleven have inadequate provisions in their factory inspection laws.

Actual tests were made under the auspices of the A. B. M. A.: At Chicago, 1893, seven drums; at St. Louis, 1897 (O'Brien), one drum; at St. Louis, 1898 (O'Brien), one drum; at Boston, 1897 (Robinson), Acushnet.

Business matters were discussed mainly in executive session at twelve conventions, and covered such items as statistics, A. B. M. A. insurance, apprenticeship, International Brotherhood of Boilermakers, consolidation, Lappan's six questions, relations with Boilermakers' Union, etc.

The social features did, perhaps in the beginning, have undue prominence, which is merely confessing that the A. B. M. A. has had the same experience as every other association of kindred industries. But they have just as necessarily been duly subordinated to our business sessions. Members who come to the convention with serious purpose find ample opportunity to learn, and instruct in turn, as knotty points come up in debate. Much important practical knowledge has been crystallized into rules of construction by combining the experience of many modest members who would not venture to write a paper. Confidence springs from personal acquaintance and induces mutual assistance in solving difficult problems. The social features thus supplement and enlarge the knowledge hammered out in the formal discussions, and cement friendships which naturally grow up among men engaged in kindred work.

We who have profited by such association earnestly desire all boiler manufacturers to join the A. B. M. A. The larger the membership the more interesting the work and the greater the benefit to the individual member.

Our workmen realize the advantage of international union. We should be as united as they.

E. D. MEIER,
New York, May 5, 1909. President A. B. M. A.

PERSONAL.

C. H. HITCH has been made master boiler maker of the Louisville & Nashville Railroad, at New Decatur, Ala.

GEORGE S. SPRATLEY has been made master boiler maker of the Frisco System, at Sherman, Tex., vice W. Huckabee, resigned.

JOHN V. TERRY has been appointed master boiler maker of the National Lines of Mexico, at Cardenas, Mexico, vice J. J. McCauley, resigned.

J. M. JONES, who for the past six months has been foreman of the Whaley Boiler Works, Providence, R. I., is now traveling salesman for the Boston Steam Specialty Company, Boston, Mass.

WILLIAM HORSLEY severed his connection with the Bigelow Company, New Haven, Conn., June 1, to take charge of the Eastern warehouse and plant of the Scully Steel & Iron Company, at Jersey City, N. J., where the Horsley pressed-steel boiler nozzles will be manufactured.

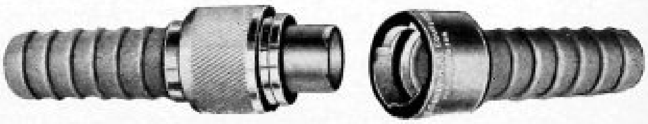
CHARLES P. PATRICK, formerly general superintendent of the Alfred E. Norton Company, Boonton, N. J., is now general superintendent of the Bigelow Company, New Haven, Conn. Mr. Patrick has also just been elected second vice-president of the International Master Boiler Makers' Association.

E. J. CODD, well known in Baltimore in the marine and boiler business, died in that city on April 17, at the age of 79 years. Mr. Codd's shop was located in the eastern district of Baltimore, where he established it about fifty years ago. His work and his word were always reliable, and his fair treatment of his patrons and employees was the secret of the importance to which his industry grew and the prominence it enjoyed at the time of his death. The business which he established will be carried on by his five sons.

ENGINEERING SPECIALTIES.

The Scully Hose Coupling.

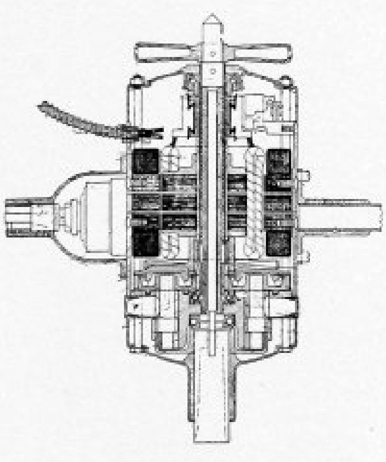
In the Scully hose coupling, manufactured by the Scully Steel & Iron Company, Chicago, the joint is made by a rubber gasket, U-shaped, which, it is claimed, is so held in place that it is impossible for it to blow out, while, at the same time, it may be easily replaced when worn out. The joint is such that as the pressure increases the joint becomes tighter, but



the coupling does not permit the hose to become twisted or kinked, and it can be instantly disconnected by a combined pull and twist of the sleeve on the male end. It is claimed that it swivels freely under the highest pressure, allowing the screwing in of connected nipples without disconnecting the hose. The coupling is made in sizes from ¼ to ¾ inch pipe and hose ends, which are interchangeable with each other. Sizes 1 and 1¼ inches pipe and hose couplings are also interchangeable with each other.

A Portable Electric Drill and Reamer.

As compared with compressed air, electric transmission for driving tools, both stationary and portable, presents a number of opportunities for a saving in power. In the first place, the feed cable for an electric tool is simpler, and can be more easily repaired than the air hose used for pneumatic tools. There is no opportunity for a leak in the transmission line with electricity, as is the case with an air hose, where a very small leak will result in the loss of several horsepower. With



electric tools there are no troubles with condensation and freezing up in winter, as sometimes happens with pneumatic tools, and it is claimed that the electric tools are free from vibration, and, therefore, easier for the workmen to handle.

The electric drill and reamer illustrated is manufactured by the Van Dorn Electric & Manufacturing Company, Cleveland, Ohio, and is capable of reaming holes from ¾ to 1¼ inches diameter. The motors are both open and closed type, with ventilation holes in the top and bottom heads and in the sides of the machine. On account of the peculiar design of the armature, the air is drawn in through the ventilating holes in the top and bottom heads and forced out through the vent holes in the side, these holes passing completely through the field opening at the air gap between the pole pieces and the armature. The machines are wound for 110 and 220 volts direct current. The upper and lower thrust bearings are ball bearings, all other bearings are of phosphor bronze. The gearing and all other wearing parts are made of machinery steel, case-hardened. The control is through the switch handle, being operated by a knurled ring. A movement of a quarter turn of this ring starts or stops the machine, so it is at all times under instant control of the operator. Each machine is equipped with an armored cable, the armor on the cable being grounded to the machine, so as to prevent the operator from getting a shock.

The Whitney Portable Hand Metal Punch.

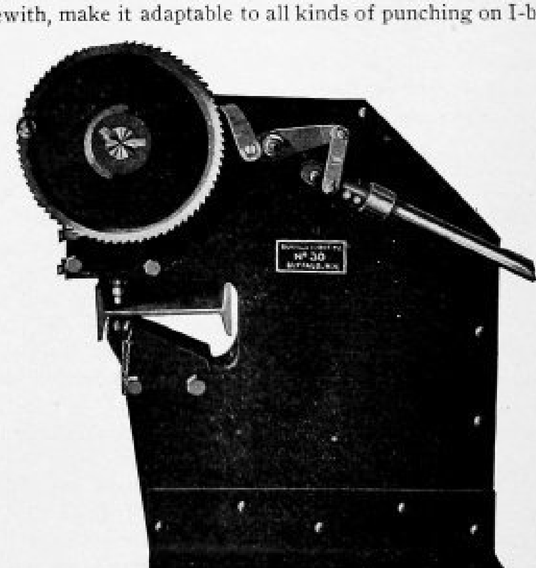
A large demand is rapidly growing among sheet-metal workers, machine shops, manufacturing plants, blacksmith shops, carriage and wagon manufacturers, etc., for portable hand metal punches. One type of these punches, manufactured by the W. A. Whitney Manufacturing Company, Rockford, Ill., is illustrated herewith.

This punch is drop-forged in its three main parts, and of best tool steel in the smaller parts. It weighs 11 pounds and

is 23 inches in length, yet punches ⅜-inch holes through ¼-inch iron, or its equivalent. The punches and dies are in thirteen sizes, ranging from ⅛ to ½ inch. The punch can be carried as a hand tool and used anywhere on a job without being held in a vise. It has been adopted by six United States navy yards and arsenals, and their machine shops are equipped with them. Many users state that the tool paid for itself with them in saving on one job.

A High-Power I-Beam and Channel Hand Punch.

While the trend of modern demands is shifting to motor and power-driven machines, yet the advantages, capacity, ease of operation and durability of the hand-power punch, illustrated herewith, make it adaptable to all kinds of punching on I-beams



from 5 inches up to 12 inches, and the extreme light weight, with the enormous power and durability, recommend it to structural steel users. The maximum capacity of this punch is 1-inch holes in ½-inch plate, which would take a dead weight of over 47 tons upon the plunger, based upon a shearing strength, of the material being punched, of 50,000 pounds to the square inch; which is equivalent to the ordinary steel used in bridges and structural steel work of all kinds. This enormous power is made possible by a combined three-stage lever motion, which has a leverage of 1 to 2,200 from the end of a 6-foot lever to the shearing edge of the punch. This is equivalent to 2,200 pounds pressure at the punch with 1 pound pull on the lever; but does not include the power lost in friction of working parts, which is small for a machine of this kind. The two frame plates are rigidly bolted and riveted together in a box form construction. The ratchet wheel is cut and hardened steel, upon which works the pawl and lever motion. It will be noticed that the lever-bearing studs are bolted through the frame, making them extra rigid, and that there are three pins in the lever handle over which the first link is placed to secure a one, two or three-tooth movement of the ratchet wheel. The ratchet wheel can be turned by a convenient handle to quickly adjust the punch to the work, as well as to run the punch up after completing an operation. The plunger crank shaft, upon which the ratchet wheel is pressed, is securely supported by flange bearings bolted to the main frame. The throw of the crank shaft is ¾ inch, and the motion is transferred to the plunger head by means of a heavy steel one-piece connecting rod, which has a width of the frame space, and is bored from the solid and bronze bushed. The planed sides of the frame form guiding surfaces on two sides of the plunger, while the main guides are bolted between the frame and have adjustable gibs, which assure the permanent alinement of the punch and die. The die holder is a steel casting of improved shape and design, adaptable to working on webs of channels, I-beams, etc. It is mounted on the frame and bolted by an extension machined to fit the frame space. Heavy angle irons are riveted to the frame on both sides, making a substantial base plate. Its weight is 1,000 pounds, and it can be mounted on a truck for portable use. The machine is made by the Buffalo Forge Company, Buffalo, N. Y., and has been styled their No. 30 punch.

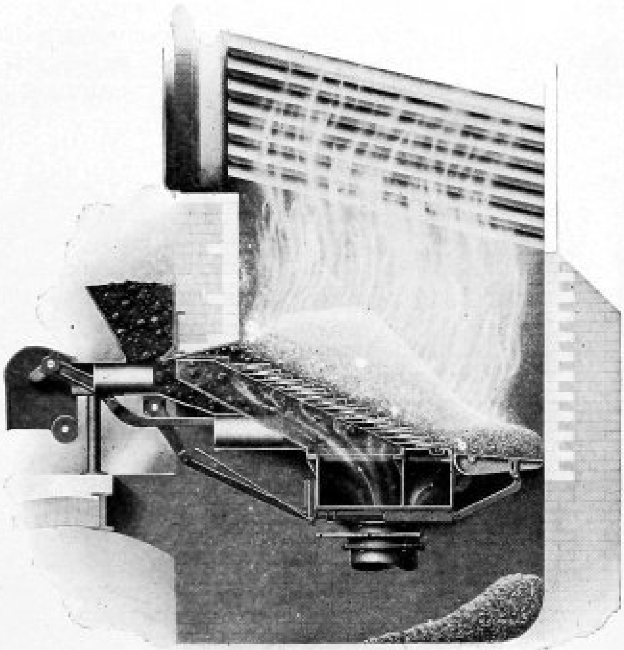
Flanged and Pressed Steel Specialties.

A visitor to the works of the Glasgow Iron Company, Pottstown, Pa., must be greatly impressed by the large quantities of wrought iron plates being made and the various uses to which they are put. An idea of the variety and excellence of the workmanship of their many flanged and pressed-steel products may be obtained from the pieces shown in the illustration. Among the numerous operations carried out and the numerous articles made in the specialty department would be noted, particularly, the flanging and dishing of heads, flanging of manholes, flue holes and handholes, reinforcing manholes, manhole saddles, flat and saddle flanges for pipe connections, "Roe" pressed-steel manheads, flanging and dishing irregular shapes, in-shearing of plates and cutting holes of any desired shape, bending plates and angles, and pressed-steel shapes of all kinds made from rolled plates. While the "Roe" manhead has been described in an earlier issue, it is not out of place to again refer to it, because of its efficiency, neatness and lightness. It is pressed from steel plate into a series of deep corrugations, the central one forming a dovetail to hold the bolt. It is claimed that the one bolt, located in the center of the head, is better than two bolts, as it draws up uniformly on the joint; whereas two bolts admit of one being drawn up tighter than the other, resulting in strains on the head and possibly a leaky joint. The one bolt in the center forms a convenient handle with the head in balance.

The Taylor Stoker.

Recent experiments have shown that an increase in the size and efficiency of boiler furnaces means a corresponding increase in the evaporative power of the boiler, while its efficiency is only slightly reduced. Realizing that boiler heating surface is far more active than is generally supposed, the Taylor stoker, manufactured by the American Ship Windlass Company, Providence, R. I., was designed with increase in boiler capacity as its chief feature. In fact it adds so much to the furnace capacity that it is claimed the boiler will evaporate 200 percent more than the rated amount. The Taylor stoker is distinguished from all others by the two words "underfeed" and "gravity," combining these two essential features. The stoker consists of a series of inclined retorts, called fuel magazines, supported on a blast box or air reservoir. The sides of the retorts are inclined air ducts capped with specially formed tuyeres, through which the air is forced from the reservoir into the fuel. There are two rams for each retort, the upper receiving the coal from the hopper and forcing it to the top of the retort, while the lower ram receives the coal as it descends and feeds it in a quantity just sufficient to maintain an even depth of fuel bed. The stroke of the ram can be adjusted to properly burn any kind of coal. The rams are moved by bell cranks and connecting links, the bell cranks being driven by crank shafts, which are connected with a speed shaft by means of worm gearing. At the end of the tuyeres, on the rear of the wind box, are the dumping plates, which are a combination dump and fire guard. The dumping plates are normally in a horizontal position; they are dropped by disengaging a pawl and catch in the connecting link, which is operated from the front of the stoker by means of a shaft and lever. The dumping plates are made in sections and can be easily taken off by removing the keepers. The stoker is driven by a positive connection from the blower engine, which is of ample power to drive all the stokers of an installation. Thus individual engines, steam piping, etc., are unnecessary.

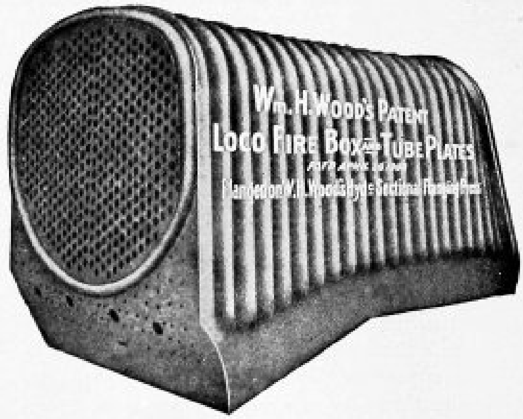
Among the advantages claimed for the Taylor stoker are the following: The draft is gentle, because of the entire absence of blowpipe action, due to the large volume of the air reservoirs and the large tuyere area. As there are no holes in the fire, the air necessary for combustion can closely approach the theoretically correct amount. There is no smoke.



Due to the underfeed feature, all the gas driven from the coal must pass through the incandescent bed and become burned. This feature gives the coal ample time to coke. The air entering through the tuyere openings unites with the volatile gases, which otherwise would cause smoke, and forms a combustible mixture. There is a marked saving of labor, for the attendant has only to supply the hoppers with coal and dump and raise the dumping plates once in a while. There is no trimming by hand, no slicing, no cleaning by hand. The furnace does not become cold from frequent opening of doors. There is no loss from fine coal dropping through the grates, for there are no grates.

Wood's Patent Firebox and Tube Plate.

For many years corrugated furnaces have been used in marine boilers, and some attempts have been made to corrugate side sheets in locomotive fire-boxes, but it is only recently that a complete corrugated fire-box, including both side and crown sheets, has been developed. In this fire-box, which was invented by Mr. W. H. Wood, Media, Pa., the sides and crown are made of a single sheet, having corrugations 1¼ inches deep spaced 5 inches apart. The bottom of the furrow is flattened to take the stay-bolt heads, and the crests are curved to a radius of 9/16 inch on the inside of the plate. The corrugations are carried down to within one stay space of the mud-ring, which is of the ordinary pattern. The plate forming the crown and sides is finished off at either end on the larger dimension of the corrugation measured internally. This allows a full-size tube plate to be used, which is also provided with a ring corrugation all around the tube portion. The front tube plate is provided with a similar ring corrugation. It is claimed that this arrangement allows much greater spring of the tube plates to take up expansion and contraction, and also that the corrugations of the fire-box make it much less rigid, resulting in less vibration of the stay-bolts. The first three rows of crown stays are specially designed sling stays for the purpose of giving added flexibility to this part of the fire-box, the remainder of the crown stays being plain radial stays. While flexibility is the main advantage



claimed for this box, and, on account of which it is expected that stay-bolt failures, leaky tubes and cracked tube sheets will be practically eliminated, there is also a reduction in the number of stays of about 350, and the heating surface of the fire-box is increased over 30 percent.

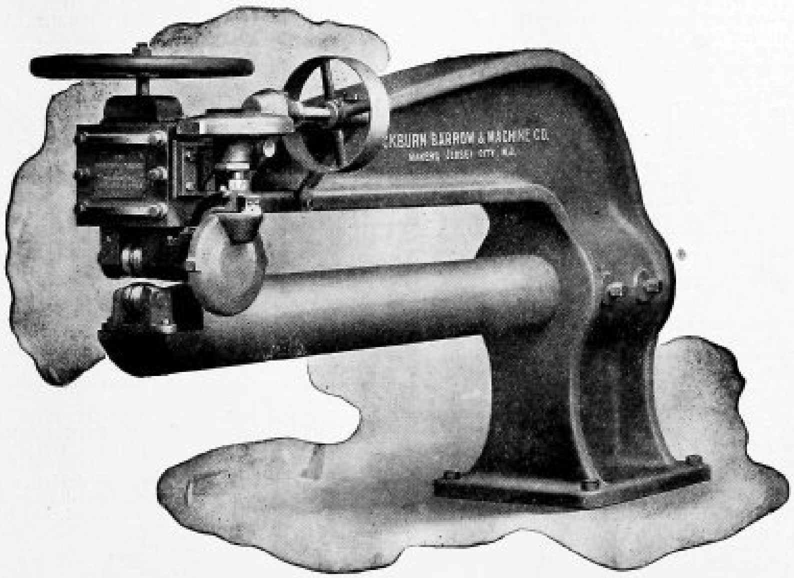
A Stay-Bolt Cutter.

The stay-bolt cutter, shown in the accompanying illustrations, and for which is claimed high economy and efficiency, is operated by hand, and will cut bolts up to 1 inch in diameter quickly and easily, leaving sufficient stock for riveting over. The bolts are sheared off neatly, leaving them tight in the boiler and eliminating the damage to bolt and boiler re-

sulting from the hammer-and-chisel method. The construction is of a type to resist the hard knocks of boiler-shop usage. The frame and levers are of steel, the eccentric links are of forged steel and the cutting tools are of the best tool steel. The cutting tool is acted on by a hardened steel roller, so that the friction is redrced to a minimum. The cutters are easily removed and extra ones for different size bolts easily inserted in the cutter slide. This valuable boiler-shop tool is manufactured by the Stow Flexible Shaft Company, Twenty-Sixth and Callowhill streets, Philadelphia, Pa.

The Cockburn Lap Seam Rolling Machine.

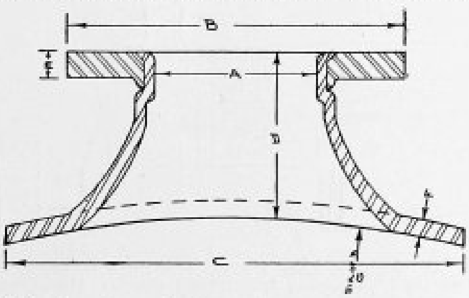
The Cockburn-Barrow & Machine Company, Jersey City, N. J., have on the market a rolling machine especially adapted for rolling the longitudinal lap seams of range boilers and



circular tanks from 9½ to 25 inches in diameter, up to 6 feet long of material from No. 14 to No. 8 gage in thickness. It is claimed that the machine will roll the longitudinal lap joints of a boiler or tank 6 feet long with one head in place in from thirty to forty-five seconds, depending upon the thickness of material. Rolling the seam in this way eliminates calking, and both the inside and outside edges of single or double-riveted joints can be rolled, making a close and tight seam. The machine is 9 feet 3 inches long, 2 feet 6 inches wide, 4 feet 9 inches high, and weighs 5,500 pounds.

Horsley Pressed Steel Boiler Nozzles.

The Horsley pressed steel boiler nozzle, which has just been placed on the market by the Scully Steel & Iron Company, Chicago, Ill., is made by pressing the body out of ⅝-inch flange steel, and the upper flange of 1-inch flange steel. The upper flange is bored, and the outside of the body is turned;



after which the flange is heated and shrunk on. Then the neck of the lower body is hammered or peened over to an angle of 45 degrees, and the flange is faced off true. The thinnest part of the neck after facing is 5/16 inch. It is claimed that these nozzles have been tested to 1,500 pounds per square inch hydraulic pressure without showing distress. Since they are made entirely of flange steel, they can be riveted on the hydraulic or power riveter and calked on the outside edge. They are made in sizes from 4 to 7 inches diameter.

The most disastrous boiler explosion known to history was undoubtedly the one which destroyed the Mississippi River steamboat *Sultana*, in 1865, says the Leavenworth "Times." The number of persons killed in that one accident was no less than 1,238. The *Sultana* and the *Luminary* left New Orleans together, on April 21, 1865, and raced up the river for Vicksburg, where many Union soldiers, just released from Southern prisons, were awaiting transportation to the North. The *Luminary* did not get the contract to carry the soldiers, and she shortly proceeded northward. About 10 hours before reaching Vicksburg, a leak developed in one of the *Sultana's* boilers, forcing her to lie over at that place 33 hours for repairs. The repairing was done, apparently, by a competent boiler maker, and it consisted in putting on a "soft patch" of ¼-inch iron plate. Previous to the arrival of the *Sultana*, the *Ames* had carried 1,300 of the soldiers North, and the *Olive Branch* had taken 700 more. It was decided to send all of the remaining men by the *Sultana*, and she took on 1,866 soldiers, including 33 paroled officers; she carried also 70 cabin passengers and a crew of 85. At about 3 o'clock in the morning of April 27, 1865, the repaired boiler on the *Sultana* exploded with tremendous violence a few miles above Memphis, Tenn. Many persons were killed outright, and many more were thrown into the river and drowned; and the wrecked vessel took fire, and was entirely destroyed. Of the soldiers, 1,101 (including 19 officers) were killed, and of the passengers and crew 137 were killed; the total number of lives lost being 1,238.

As showing the comparative cost of boilers, Prof. C. H. Benjamin, of Purdue University, gives in *Steam* the following figures: In 1890 the cost of a 150-horsepower horizontal tubular boiler was $1,500, and in 1906, $1,010. For a water-tube boiler the cost in 1890 was $2,700 and in 1906, $1,420. These figures are, of course, averages and would be subject to considerable variation in individual cases. The price at the present time would also be considerably different.

The American Locomotive Company has recently purchased property at Gary, Ind., for the erection of the largest locomotive building plant in the country. The site covers 130 acres, which is twice as large as any site now occupied by this company. From twelve to fifteen thousand men will be employed in the new plant. The location of the plant is exceptionally good, as it is near the immense new steel plant of the United States Steel Corporation and has exceptionally good shipping facilities.

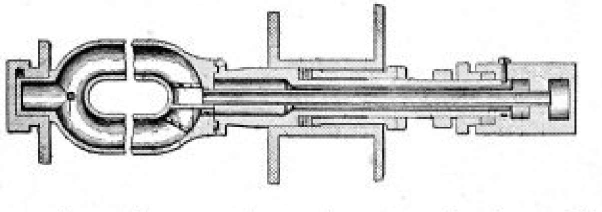
SELECTED BOILER PATENTS.

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

916,609. WATER-COOLED GRATE-BAR. PETER G. SCHMIDT, OF TUMWATER, WASH.

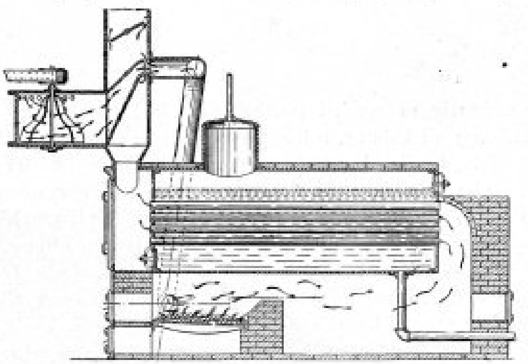
Claim 2.—A hollow grate-bar having fluid passages communicating with each other at one end of the grate-bar and separated at the other end thereof, one of said passages being connected with a source of fluid supply and the other provided with an outlet, and a barrier disposed



within and extending across the grate-bar at the outlet of one of the fluid passages, said barrier having its upper portion spaced from the adjacent wall of the fluid passage thereby to form a partial obstruction to the flow of fluid through said passage to the outlet. Twenty-two claims.

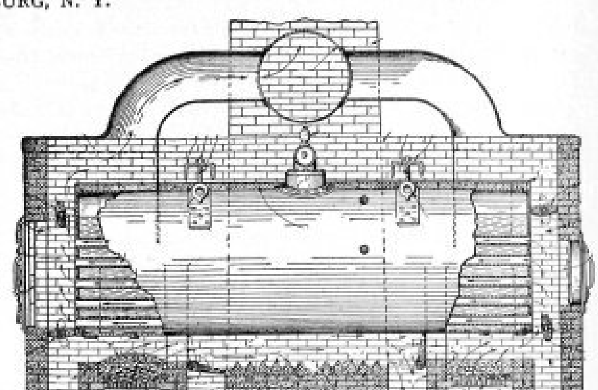
916,910. SMOKE-CONSUMING FURNACE. RICHARD BOERSIG, OF DENVER, COL.

Claim 1.—The combination with a fire-box and a source of compressed air, of a smoke flue or stack provided with a hood relatively large at the base where it is in communication with the source of compressed air, and extending upwardly across the stack, occupying an inclined position



and terminating in front of an outlet opening with which the stack is provided, the said hood tapering from the base to its upper extremity, a short pipe leading from said outlet opening and occupying a horizontal position, and two downwardly-extending conduits communicating with the said pipe at their upper extremities and with the fire-box above the grate at their lower extremities. Two claims.

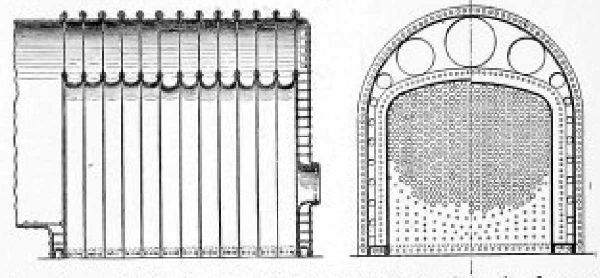
916,996. APPARATUS FOR PRODUCING COMPLETE COMBUSTION. JOHN CARTIN, OF OGDENSBURG, N. Y., ASSIGNOR OF ONE-TENTH TO J. WILLIAM EMOND, ONE-TENTH TO WILLIAM EMOND, ONE-TENTH TO JOSEPH EMOND, AND ONE-TENTH TO WILLIAM P. KAUFMANN, OF CARDINAL, CANADA; ONE-TENTH TO ANTHONY WHITE, AND ONE-TENTH TO PHILIP J. CARTIN, OF WATERTOWN, N. Y., AND ONE-TENTH TO THOMAS J. HALL, ONE-TENTH TO FRANK P. CARTIN, AND ONE-TENTH TO JOHN H. CARTIN, OF OGDENSBURG, N. Y.



Claim 7.—The combination of a boiler suspended horizontally and having flues therein, a casing surrounding said boiler and being spaced therefrom at its ends to form flues, the space between the side walls of the casing below the boiler forming a combustion chamber, a pair of dampers journaled for rotation in each of said flues, said dampers being normally at right angles to each other, means to operate each pair of dampers simultaneously to control the flow of products of combustion through the boiler flues, a fire-box beneath each end of the boiler, each fire-box comprising a pair of partitions and a grate, one of the partitions being formed with an upper and a lower arch-way, a bridge located centrally in said chamber beneath the boiler, said bridge comprising a plurality of spaced refractory bars, and means within said chamber to control the passage of products of combustion from one fire-box to the other by way of either of said arch-ways. Nine claims.

917,172. SECTIONAL FIRE-BOX. FRANK W. SHUPERT, OF SAN BERNARDINO, CAL., AND HENRY W. JACOBS, OF TOPEKA, KAN., ASSIGNORS TO THEMSELVES AS TRUSTEES.

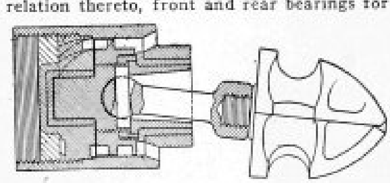
Claim 8.—In a boiler, the combination of a shell, a flue sheet, an inner back sheet, sheet metal sections forming the fire-box, said sections having



outwardly projecting flanges that are secured together, the front section being secured to said flue sheet, and the rear section being secured to said inner back sheet, and stays connecting said sections with said shell. Fourteen claims.

917,211. FLUE CLEANER. HENRY F. WEINLAND, OF SPRINGFIELD, OHIO, ASSIGNOR TO THE LAGONDA MANUFACTURING COMPANY, OF SPRINGFIELD, OHIO, A CORPORATION OF OHIO.

Claim 1.—In a boiler-tube cleaning device, a rotatable motor comprising a runner, a casing therefor adapted to protect the runner and stationary in its relation thereto, front and rear bearings for the runner, a



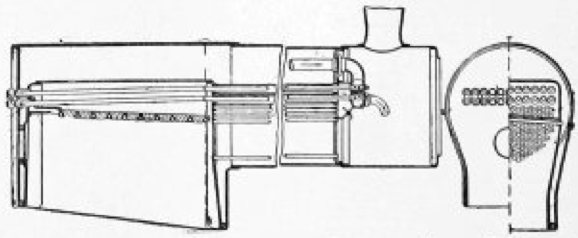
cleaner carrying member pivoted within the motor between said bearings and rotated thereby and adapted to swing outwardly from the axis of the motor, said cleaner-carrying member being driven solely by the rotation of the runner. Five claims.

917,380. BOILER-CLEANING DEVICE. ADOLPH THOMAS AND EDGOR THOMPSON, OF MINNESOTA LAKE, MINN.; SAID THOMAS ASSIGNOR TO NORBERT THOMAS, OF WHEATON, MINN.

Claim 1.—In a cleaning device, the combination with the shell of a boiler or the like, of inner and outer cleaning pipes arranged within the same and formed with slots adapted to be moved into and out of register with each other, a shaft, means for hanging the outer pipe from the same, means between said shaft and the inner pipe for rotating the latter within the outer one and means for rotating said shaft. Six claims.

917,668. SUPERHEATER. WILHELM SCHMIDT, OF WILHELMSHOEHE, NEAR CASSEL, GERMANY.

Claim 2.—In a tube superheater, for use with boilers of the locomotive type, the combination of superheating tubes extending from the smoke-box of the boiler through boiler smoke tubes and fire-box and through the back wall of the boiler, and a protecting cross-wall for said tubes



where they pass through the fire-box, said cross-wall comprising sections separated but overlapped to form a passage to the superheater for fire gases while cutting off direct radiation from the fire and at least one of said cross-wall sections being constituted of transverse water tubes with fire-brick laid thereon. Ten claims.

919,462. STEAM-BOILER APPLIANCE. JAMES ARCHER RAY, OF WICHITA, KAN.

Claim 1.—The combination with a steam boiler having a smoke flue, a feed-water pipe, and a fire-box provided with a water jacket, of a water-purifying compartment located above the lower portion of said water jacket, a strainer and filter pipe at the upper portion of said purifying compartment, a pipe having connection at its lower end with said water jacket and at its upper end with said strainer and filter pipe, and a vertical pipe in said smoke flue having at its upper end connection with said feed-water pipe, and at its lower end connection with said water-purifying compartment, said vertical pipe having a hot-water pipe connection with the boiler. Four claims.

THE BOILER MAKER

JULY, 1909

THE DIAGONAL PATCH.

BY R. E. M'NAMARA.

In horizontal tubular boilers of the inverted front-head type, such as shown in Fig. 1, and which, when set in place ready for use, have what is known as the half-arch front setting there is occasionally a tendency for the sheet to bag, as illustrated at "A," Fig. 2. This may be due to various causes; the brick lining of the front may crumble away, exposing the unprojected joint of the front head girth seam to the furnace heat; an unusual amount of scale may accumulate at the point in question or in the annular pocket always found in conjunction with this type of manufacture. At any rate, when bagged serious enough to warrant, it is up to the boiler maker to recommend and execute such repairs as may be consistent with good practice, including safety and economy. Heating and driving back is frequently adopted for small bags. Where the bulged area takes in several square feet, however, and it is thought that the strength of the affected portion is somewhat lower than the longitudinal efficiency, heavy repairs, such as half sheets, are generally recommended, costing for an ordinary 72-inch by 18-foot by 7/1*-inch boiler about $350, being at once an expensive undertaking, and considering that this size of boiler in up-to-date construction is provided with a triple butt joint of 86 percent efficiency in a longitudinal direction when half sheets are applied, the seam will in most cases be of the double riveted lap style having an efficiency of 65 percent or less, thus detracting in general from 20 to 30 percent from the safe working pressure of the boiler. Where conditions will permit, the application of a diagonal patch will partially eliminate the obnoxious features outlined above.

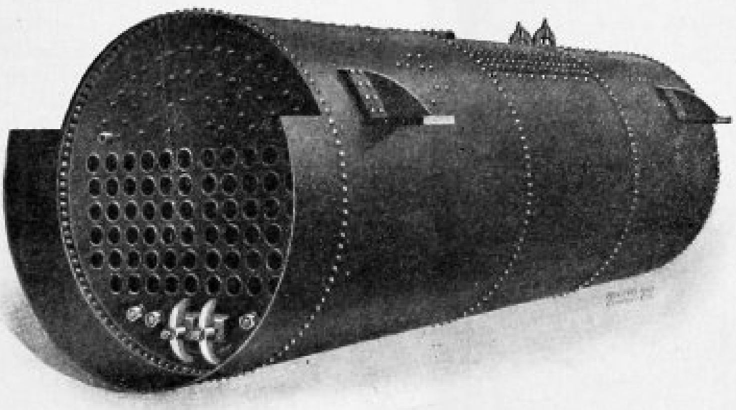


FIG. 1.

The diagonally jointed boiler, Fig. 3, has not as yet come into general use for various reasons. As the methods applicable to their calculation differ somewhat from the ordinary riveted style, a few words as to the designing of a diagonal patch or helical-seamed boiler may not be out of place. In calculating the efficiency of an ordinary longitudinal and girth joint, the seams are studied for the different methods or points at which failure may occur, either the rivets or the net section of plate may be the weakest. The efficiency is taken as the ratio of the strength of the solid plate to that of the weakest portion, whether it be net section or rivets; then 100 times the weakest, divided by the strongest-joint efficiency in percentage. In handling diagonal joints, the term efficiency does not fully convey the meaning required which is essential to an understanding of the problem. "Effective efficiency" are the ideal words applicable to diagonal joints, for as we know that a boiler has twice the strength in a girthwise direction that it has longitudinally it follows that if a boiler had a longitudinal single-riveted lap joint of 50 percent efficiency, if the girth seams were identical in construction, the efficiency as ordinarily calculated would only be 50 percent, but the effective efficiency would be at least twice 50 or 100 percent; it is often much more, for the tubes themselves amply stay that portion of the heads to which they are attached and besides subtract considerable area from the heads, consequently deducting a major portion from the pressure which tends to part the boiler at the girth seams. Therefore, the efficiency of a 50-percent girth seam as ordinarily calculated may have an effective efficiency of 150 percent, especially at the bottom half of a boiler where the tubes come out closer to the shell.

To prove the virtue of strength relative to longitudinal vs. girthwise stress in a boiler shell, we will assume a 60 inches by 16 foot horizontal tubular boiler with a ½-inch plate of 60,000 pounds tensile strength and, for convenience in calculation, jointless; the pressure tending to burst the shell in a longitudinal plane will be measured through the greatest plane that can be drawn through the boiler's diameter (60¼ inches in this case), a belt or ring of any width can be taken, 2 inches in formula, the equation will dispose itself thus:

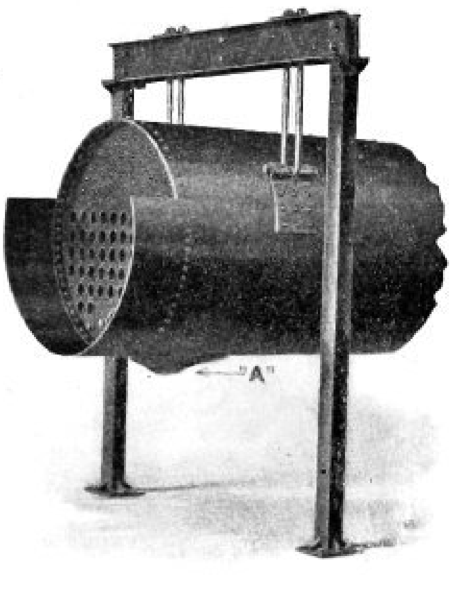


FIG. 2.

$$\frac{2 \times \frac{1}{2} \times 60{,}000}{60 \times 2} = 1{,}000 \text{ pounds.}$$

The strength of the shell in a girthwise plane equals $60 \times 3.1416 \times \frac{1}{2} \times 60{,}000 = 5654.88$ pounds = strength of metal. The area of a 60-inch head $= 60 \times 60 \times .7854 = 2827.44$, then

$$\frac{5654.88}{2827.44} = 2000 \text{ pounds.}$$

Then $2{,}000 \div 1{,}000 = 2$, showing that a shell is twice as strong at the girth seams.

It follows, therefore, that any joint whose angular parallax approaches to or recedes from the girth seam may be made to partake of a portion of its strength which, as this will be a diagonal joint, will have an effective efficiency according to the following formula:

$$\frac{2}{\sqrt{\text{Cosine of angle of inclination}^2 \times 3 + 1}}.$$

As a table of cosines is not always at hand, the calculations for the various angles that may be met with in ordinary practice have been calculated and are arranged below as factors (taken from "Locomotive," July, 1897):

Angle.	Factor.	Angle.	Factor.
30°	1.51	47°	1.24
32°	1.47	50°	1.20
35°	1.42	52°	1.18
37°	1.38	55°	1.15
40°	1.34	57°	1.13
42°	1.30	60°	1.11
45°	1.27	65°	1.08

Thus, in a single-riveted lap joint, 5/16-inch plate, 11/16-inch rivet holes, pitch 1 47/64 inches, 60,000 pounds strength of plate, 42,000 pounds rivet resistance, the shearing strength of the rivets will be 18,552 pounds, net section of plate 18,551 pounds. As the strength of the solid plate is 32,614 pounds, the ordinary efficiency will be practically 60 percent. When inclined at an angle of 30 degrees its effective efficiency will be factor $1.51 \times 60 = 90$ percent. This may be increased somewhat by decreasing the rivet pitch to 1⅝ inches, thus increasing the rivet resistance, and as in this case we are assuming the joint comes on the bottom half of the boiler, it is in a measure supported by the staying effect of the tubes. Under ideal conditions, therefore, the effective efficiency will approximate 100 percent.

No exhaustive tests (of which the writer is aware) have been made to substantiate the merits of diagonal patching; in theory and practice, however, the diagonal joint possesses extraordinary and valuable features. Fig. 4-A represents such a patch as advocated, but not originated by the writer. Applying it in ordinary practice, it is well to keep under the angle 45 degrees as much as possible, in order to take advantage of the correspondingly high factor. Assuming the defective portion (*B*, Fig. 4) is to be cut out and replaced with a diagonal patch, along the bottom center of a boiler, mark the line *CL* of suitable length, perpendicular to it and back far enough to clear the defective portion mark line *P-P*, extending to each side sufficiently to allow the measurement of angle *G*. Points *X-X* are now to be found by trial, using judgment as to the amount of material to be removed, also keeping in mind the desired obliquity of the angle *G* and not allowing the diagonal *D* to run into a rivet hole in the head-girth seam. When these trial points are found and their position fulfills the requirements, with a flexible straight edge mark the diagonals *D-D*, whose extremities *E-E* will, if accurately drawn, be equidistant from any point in line *LC*. The diagonals *D-D* and from points *X* to *X* will be the line for the cut out to follow,

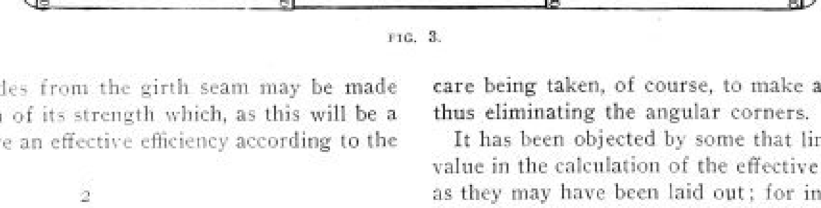


FIG. 3.

care being taken, of course, to make a gradual curve at *X-X*, thus eliminating the angular corners.

It has been objected by some that lines *D-D* have a variable value in the calculation of the effective efficiency. Accordingly, as they may have been laid out; for instance, in the plan view (Fig. 4, *A* and *B*) the diagonals, as viewed perpendicularly, have the appearance of a straight line; oblique angles on a cylinder, however, when the cylinder is unrolled, present an outline of irregular curvature. Fig. 5, *A* and *B*, being a reproduction and layout of Fig. 4, *A*; it will be observed that the apparently straight diagonal lines, when viewed on a flat sheet, stretched out, are curved. There are other conflicting elements which play some part in the absolute calculation of these joints; the tables, however, for lap joints may be relied upon for slight discrepancies; errors, if any, are on the side of safety.

After having removed the defective portion (Fig. 4, *B*) the rivet line is laid out on the shell for 7/16-inch plate, 1⅜ inches back of and parallel to the cut. The rivet holes are then

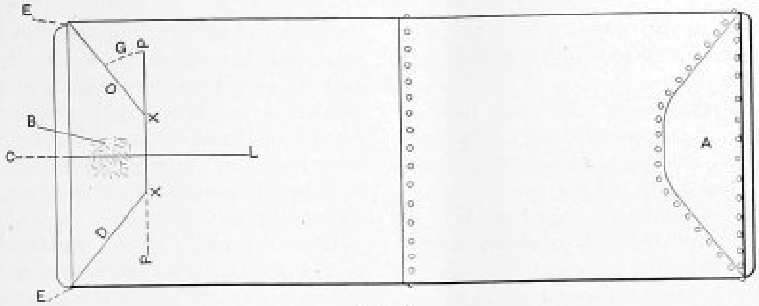


FIG. 4.

spaced off with the dividers, using 2 inches for centers on the diagonal cut; this patch may be slightly changed, however, to make the spacing come out right between points *X-X;* the holes are then drilled, the burrs removed and the inner portion of the sheet where the patch is to come should be well cleaned and filed bright. The size of the new patch may now be taken by measurement, or it may be laid out from the sketch plate (Fig. 5, *B*). The upper corners of the patch are now scarfed where they are to fit in between the head and the old sheet.

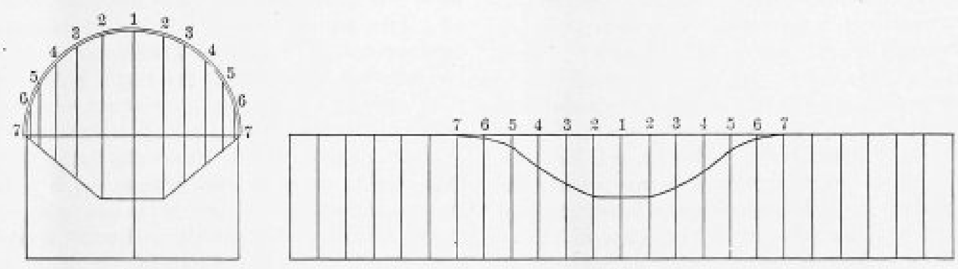


FIG. 5.

After being rolled and the edges fullered, the patch is put in place. If the work has been handled by a competent man he will previously have had the holes put into the sheet where it is to be riveted to the head; these holes may now be used to help bolt and pull the patch in place. The back of the sheet will not likely fit snug enough to admit of all the holes being marked, and it may therefore sometimes be necessary to work a jack from the inside of the boiler to bring the two sheets metal to metal. The holes are then all marked, the sheet taken down and drilled, and any surplus stock on the edges removed,

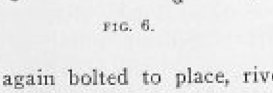


FIG. 6.

after which it is again bolted to place, riveted and calked. When applied in a workmanlike manner, a standard boiler may be thus repaired without reducing the safe working pressure but a few pounds, if any. While horizontal tubular boilers were specifically mentioned in this article, these patches will also apply to the drums of watertube boilers of standard makes, such as the Heine, Babcock, etc., as those drums generally have a large margin of safety; in general the safe working pressure will not be affected at all.

To those who are further interested in the calculation of these joints, the trigonometrical equivalents and diagram appended below may be of interest. The table also gives the cosines for use in the formula. (From Lukens Hand-Book):

TRIGONOMETRICAL FUNCTIONS.

Let angle *A O F*, Fig. 6, be denoted by C; $O A$ = radius R = 1, then

Sine	$C = FG$
Cosine	$C = OG$
Tangent	$C = AL$
Cotangent	$C = DL$
Secant	$C = OL$
Cosecant	$C = OL$
Versed sine	$C = GA$
Coversed sine	$C = DK$

TRIGONOMETRICAL EQUIVALENTS.

Sine	$= \sqrt{1 - \text{Cos.}^2}$	Cos.	$= \sqrt{1 - \text{Sine}^2}$
Sine	= Cos. ÷ Cotan.	Cos.	= Sine ÷ Tan.
Tan.	= 1 ÷ Cotan.	Cos.	= Sine × Cotan.
Cosec.	= 1 ÷ Sine	Tan.	= Sine ÷ Cosine
Secant	= 1 ÷ Cos.	Cotan.	= Cosine ÷ Sine
Vers.	= Rad. — Cos.	$(\text{Rad.})^2$	$= \text{Sine}^2 + \text{Cos.}^2$
Covers.	= Rad. — Sine	$(\text{Sec.})^2$	$= \text{Radius}^2 + \text{Tan.}^2$

Cotan. = 1 ÷ Tan.

Angle.	Cosine.	Angle.	Cosine.
30	.5000	47	.7314
32	.5299	50	.7660
35	.5736	52	.7880
37	.6018	55	.8192
40	.6428	57	.8387
42	.6691	60	.8660
45	.7071	65	.9063

Applying the formula in using the cosine we have for an angle of 35 degrees

$$\frac{2}{\sqrt{(.5736 \times .5736 \times 3) + 1}} = 1.42.$$

This number will be found under factor and opposite 35 degrees, indicating that if we have a lap-riveted joint of, say, 70 percent efficiency, inclining it at an angle of 35 degrees, will give it an effective efficiency of 1.42, multiplied by 70 equals 99 percent, practically as strong as a solid plate. In boiler shells, where the heads are partially supported by tubes or furnaces, the effective efficiency, as previously stated, may often approximate 150 percent.

As an illustration of the strengthening effect of a furnace tube in a boiler, the calculations pertaining to a 60-inch diameter Scotch type of boiler may be cited, assuming the following data: One-half-inch steel plate, 60,000 pounds tensile strength, 30-inch furnace tube. The area of the head is $60 \times 60 \times .7854 = 2827.44$ square inches. (The area of the furnace tube is $30 \times 30 \times .7854 = 706.86$ square inches.) Then $2827.44 - 706.86 = 2120.58$ = area exposed to pressure. The circumference of shell $= 60 \times 3.1416 = 188.49$ inches. The circumference of flue tube $= 30 \times 3.1416 = 94.24$ inches, then $188.49 + 94.24 \times \frac{1}{2} \times 60{,}000 = 8{,}482{,}320$ pounds resistance to internal pressure; $8{,}482{,}320 \div 2120.58 = 4{,}000$ pounds bursting pressure in a longitudinal direction. The bursting pressure in a transverse direction $= \dfrac{60{,}000 \times \frac{1}{2}}{30} = 1{,}000$ pounds, $4{,}000 \div 1{,}000 = 4$, showing that a 60-inch jointless shell, when strengthened by a 30-inch by ½-inch internal tube is four times as strong in the girth seam plane as it is in a longitudinal plane. The bursting pressure in a girth-wise plane, without the additional strength of a furnace tube, would be 2,000 pounds.

In conclusion, therefore, we might state that when cost and results are compared, in the first case of half sheets, the expenditure will be about $350, and a reduction of some 25 percent from the working pressure; when diagonal patches are substituted instead the cost will approximate $100, the time consumed one-third, and the reduction of pressure in favorable cases need not be reckoned.

Advisability of Installing Hot-Water Washouts and Filling Systems.*

BY LUTHER H. BRYAN.

Having been appointed by our president to write a paper on the above subject, it will be necessary for me to go a little into detail before I tell you my reasons why it is advisable to install a hot-water wash-out and filling system.

You all know that the most important part of a locomotive is the boiler, and it is just as essential, if not more so, to keep it free from mud and scale as it is to keep up the machinery. Mud and scale are due to the impurities in the water; after the water has passed through the injector or pump and is generated into steam, the impurities are left behind and form mud; this is deposited around the tubes, on the inner side of the shell of the boiler, and on the mud-ring, and after a short time this becomes hardened and forms what we term scale. This scale is found in numerous forms, depending on the locality; in some parts of the country a greater amount will be deposited than in others. This is especially true in the alkali districts, causing the boilers to be washed out as often as once each trip. It is up to the man in charge of the mechanical department to determine how long an engine should run or, rather, how many miles it can safely make between wash-outs; and should the engine go too long between washings, the consequence would be leaky tubes, cracked flue and side sheets, mud-burned places and the like, causing delay to traffic, undue expense for repairs, extravagance of fuel, etc. Another important factor is to get a first-class man to do the washing. The position of boiler washer is one of the hardest places to get competent men for. The men are continually working in the water, and for that reason no one cares particularly for the job. The position should be placed in the skilled column, and none but skilled workmen should be employed; the pay should be attractive enough to hold them; as it is now they are paid about the smallest wages in the service. It is a grave mistake to think we can get good results from a poorly paid class of labor, especially when we stop and think how much money is invested in our modern locomotives. If the truth were known there are more engine failures due to poor boiler washing than from any other cause.

There are two ways of washing boilers: the old way with cold water and the new way with hot water. I am inclined to believe that the cold-water process is fast going out of use. It has been demonstrated beyond a doubt that cold water is a poor ingredient to put into a boiler after the hot water has been drained and the sheets are still hot. This is very often the case when the available power is limited and engines are badly needed.

To wash an engine where cold water is used, it should require from six to eight hours. An engine comes in off the road under full head of steam and is booked for wash-out. It is first necessary to blow off all the steam; this is usually done by connecting a pipe or hose to the steam chest relief valves, or to the syphon cock in the dome, and steam is carried off to the atmosphere outside the round-house; but it often happens that the workman does not wait to attach hose, and the steam is blown off in the round house; this practice, besides making a deafening noise, rusts up everything from the deposit of moisture left behind. This takes about an hour. While the steam is being blown off, the boiler washer connects up a hose to the feed-water pipe to the injector and the water system, and as soon as the steam is low enough he opens the valve and fills the boiler with cold water, opening the blow-off cock to allow the hot water to run off at the bottom; this continues until the water coming out of the blow-off cock is cold. This consumes another hour. After this the man waits until the water in the boiler has lowered enough to remove the wash-out plugs; another 30 minutes gone. He then starts to wash the boiler, and, in order to do a first-class job, should take at least an hour and thirty minutes. He then replaces the plugs and fills the boiler with cold water; another 45 minutes. The fact that the water is cold will take at least two hours to get the engine hot enough to move, unless a forced draft is used, when the time can be cut down some. This makes a total of about seven hours to bring an engine into the round-house hot, giving the boiler a thorough washing out, and setting her on the outgoing track ready for business.

By the use of the hot-water system the time can be greatly reduced, without injury to the boiler. An engine comes in off the road under a full head of steam, and is placed in the section of the round-house with a cement floor.

In the operation of this system, the steam and water is blown out of the boiler through the blow-off cock into the blow-off main, which is a 4-inch wrought iron pipe running around the round-house with 2-inch drops between the stalls; this hot water and steam passes into a filter and strikes a baffle-plate, which separates the steam from the water, the steam passing into an open heater. The steam and water in going to the filter passes a flap valve, which is connected to the cold-water line; opens it, admitting cold water to the heater while the engine is being blown off. The steam entering the heater, heats the cold water automatically admitted by the blown-off water and steam, in sufficient quantity to refill the boiler. This heated water flows from the open heater to a storage tank, where there is placed a thermostat which controls a live steam valve. This valve is open when the temperature in the filling-water tank is below any desired temperature, about 170 degrees F.; at this degree of heat, the thermostat operates and the live steam valve is closed, thereby automatically maintaining and insuring filling water at that degree; however, this valve is seldom used, as the steam that

* Read before the International Railway General Foremen's Association, June, 1909.

is blown from the engine will keep this water the proper temperature. There is also a valve connected to a float in the filling-water tank that regulates the admission of fresh water, so that there is always a minimum amount of hot water for filling purposes. The hot water is pumped from the filling-water tank and discharged into the 4-inch pipe running around the round-house, and thence into the 2-inch drop pipes between the pits, where a hose may be attached for filling the engine boilers through the blow-off cock. The water from the filter passes through a perforated, cone-shaped affair, thence through filtering material, and flows into the wash-out water reservoir. By this means of purification and storage the greatest amount of waste heat blown out of the locomotive may be saved. The temperature of the water from the wash-out tank will average 180 degrees F. Wash-out water cannot be safely handled at much above 140 degrees, so in order to regulate this, the cold-water line is connected to the hot-water suction line, which runs from the wash-out water tank to the wash-out pump, and a thermostat or tempering valve is placed in the pump pit, so that the wash-out water pumped around the round-house and into the drop lines, never gets above 150 degrees. From the bottom of the filter is a pipe leading to a refuse or sludge tank, where all the mud and scale that is blown into the filter is deposited. Daily this tank is cleaned out by opening a valve to the sewer and the refuse dumped. A locomotive boiler can be emptied of steam and water in about 20 to 25 minutes; washed thoroughly with hot water in from 45 minutes to an hour; filled with water at 170 degrees in another 30 minutes, and steam can be raised on an engine in less than 30 minutes, a total of about 2½ hours at the most, a saving of from 4 to 5 hours with the hot-water system over the old way. I wish that I might have had time to give you a few figures showing the actual saving of the hot-water system over the old way. It would be a difficult matter to get the actual money saved when you take into consideration that the round-house is kept free from escaping steam, no noise incident to the blowing off, no waste of fuel heating the water when firing up, no waste of fuel or labor in heating the water for washing out or refilling; all the exhaust steam is utilized; the boiler, fire-box and flue repairs are reduced, the train delays are lessened, the locomotives are kept in almost constant use, and the cleanliness about the round-house is a big item. I would certainly recommend to any railway system the immediate adoption and installation of a hot-water wash-out and filling system.

Location of the Point of Water Delivery.*

BY W. H. KIDNEIGH.

Would it be an advantage to locate the point of water delivery in the boiler at a point from 6 to 8 inches above the mud-ring, just in the rear of the throat sheet, rather than in the front end of the boiler near flues?

Having introduced this topic, I wish to say that I have given this considerable thought, and am of the opinion that a delivery of water at or near this point would have some favorable advantages, the sediment deposited by the water injected at the front of the boiler and near to the top of the flues, as you know in some cases where the flues have not been changed for some time, fill up solid between flues for 20 to 30 inches each side of the boiler check, and thick scale forms for a much greater distance, there being practically no way of getting at this sediment when washing boilers, wherein if water was injected close to the mud-ring, this sediment could be easily removed, and, also, water injected at this point would, in my opinion, create a circulation that would be of great benefit.

* Read before the International Railway General Foreman's Association, June, 1909.

Some of the Advantages and Economies of Hot-Water Locomotive Washout and Refilling Systems.*

BY R. W. WOODS.

Probably the most important advantage in a hot-water system is the rapidity with which work can be done, enabling you to get the engine into service from two to three hours quicker than you could possibly do with a cold-water system, which necessitates cooling the engine down after the steam has been blown off, and stands from two to three hours in the round-house before the boiler can be washed out. The average time to wash out and get the engine ready for service varies from one and one-half to four hours.

Some of the other benefits derived are as follows: No evidence of steam in the round-house, which makes it possible for the men to do more and better work; it gives the foreman a clear view of what is going on in the house, and enables him to give directions, and the men to communicate with each other without groping around in the steam to find each other or their tools.

The noise of blowing off is reduced so that it is hardly noticeable, ordinary conversation taking the place of shouting.

All this hot water for washing out and refilling is heated without extra cost for fuel or labor, because it is heated by what otherwise would be thrown away, and no expense is entailed for operation and maintenance over the cold-water methods.

By using hot water for washing out boilers they are not only kept cleaner than with cold water, but are washed quicker; thus better results are obtained at less cost of boiler-washing labor. Plenty of hot water to refill boilers, the high temperature of water reduces time and fuel necessary to get engines hot, reducing overtime, reducing time at terminals where washing out is necessary. The saving of time in the round-house in busy seasons amounts to more than anything else I have mentioned, and this amounts to cutting the time in half for washing out.

In conclusion, it would be a great saving to have the boilers washed out and refilled with hot water, and the saving obtained by doing so would pay a good interest on the investment.

A FIREBOX PATCH.

BY J. P. MORRISON.

There is no line of work connected with the sheet-metal trades which requires better judgment, a more thorough knowledge of conditions and more ingenuity than does the repairing of old boilers; and this is especially true when the parts repaired are located where they receive the direct impact of the heat. Such is the case with locomotive fire-box repairs. Usually the best mechanic available is given this work, and there are cases, where out-of-ordinary conditions exist, calling for the greatest care and foresight, and the opinion of others is called for before a satisfactory solution is reached. The work described in this article is of the nature referred to, and while in shops with full equipment for handling work of this kind the repair would have been comparatively simple; in the shop in which the work was done no other method was possible without serious delay, and the contract for making the repair was secured on a promise of quick work.

The work was necessary on account of the side sheets of the fire-box cracking between the stay-bolts. These cracks had been calked with fillers, chisels and center punches until the sheets presented a unique appearance; the cracks in the mean-

* Read before the International Railway General Foreman's Association, June, 1909.

time gradually extending to the next stay-bolt, and then to the next, until patching was the easiest way out of the difficulty. Upon investigation it was decided to remove a section of the side sheet, four bolts wide and five bolts high, as shown in Fig. 1, thus cutting away the cracked sheet.

After the size of the patch had been determined, the next step was to layout the cutting line on the fire-box sheet. This was done by using a steel square and scratch awl, the latter being No. 1 of the tools illustrated. The location of this line was determined by allowing sufficient distance between the stay-bolts and line to pass the cape chisels and ripper used in cutting the sheet. This distance should be about ¼ inch, and that was the distance taken in this case. Having marked on the sheet the ¼-inch distance from the stay-bolts at the top, bottom and sides of the corner bolts, connect these marks with a scratch line, which should be prick-punched. Round the corners, using the stay-bolts at the corners as centers. Then you have the sheet marked very similar to the line marked "Sheet Cut Here," Fig. 1.

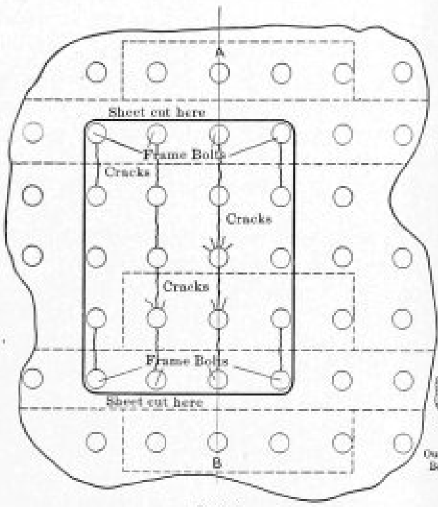


FIG. 1
SECTION OF FIRE BOX

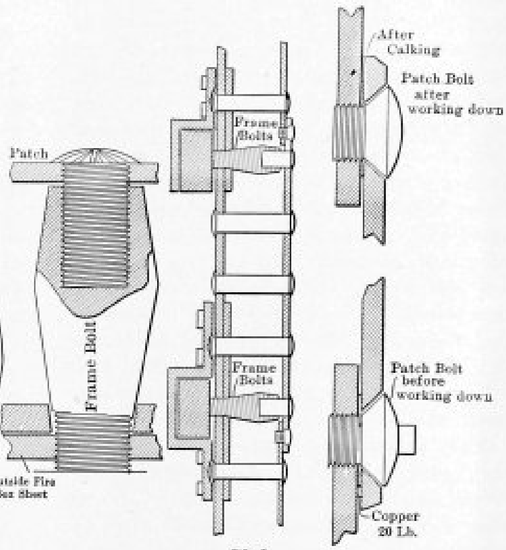


FIG. 2
CROSS SECTION
A-B- FIG. 1
AFTER SHEET IS PATCHED

CROSS SECTION

From the line made allow 1⅛ inches outside of the cutting line for the patch-bolt line, it being necessary to put the patch on with patch-bolts, because it is not possible to hold on rivets in work of this kind. The 1⅛-inch allowed is the inside lap, and the patch-bolt line should parallel the cutting line, being scratched very plainly, but not prick-punched.

Where the patch is near the grates, as in this case, it is best to remove the grates and grate-bars, for the time taken in so doing will be more than saved in being able to work to an advantage after the grates are out.

While the boiler maker and helper have been removing the grates and laying off the patch, the machine shop force have removed the expansion plates, holding the frame to the boiler, and behind which several of the stay-bolts are located. On account of the expense of removing the frame, the bolts behind it, eight in number, are to be put in steam-tight. The ends of the exposed bolts are centered, the helper rigs up an "old man" for drilling them out, and the boiler maker is engaged in cutting the sheet along the prick-punched line in the fire-box. For drilling the stay-bolt ends at the outside sheet, as large a drill as possible should be used. The size depends upon the ability of the workman. If the bolts are accurately centered and the helper is able to drill a straight hole without letting the drill "run," an inch-drill may be used for removing 1⅛-inch bolts, but usually it is better to use a ⅞-inch or ¾-inch drill, as there is less liability of injuring the sheet. The holes should be drilled about 1 inch deep. This will clear the reinforcement plate on the inside of the outside sheet; but if this plate does not extend to these holes they may not be drilled so deep.

Some use a diamond point for cutting the inside sheet along the prick-punched line, but in this work cape-chisels and a ripper (Nos. 2 and 3, Fig. 3) were used. Two cuts with a cape-chisel should be taken; then remove the remainder of the sheet with the ripper. The first chisel used should be at least ¼ inch across the cutting face, and the second cape-chisel should be ground so as to just clear the first cut. Then there will be no trouble with the cape sticking. The ripper should clear the second chisel, and should be hollow-ground across the cutting edge. The cut with each cape will remove approximately ⅛ inch of the plate, leaving an eighth of an inch for the ripper, where the side sheet is ⅜ inch in thickness. The sheet will be cut in about six hours, "a foot an hour" being a fair amount of work where ⅜-inch plate is ripped. In this time the helper has drilled the outside ends of the stay-bolts. The helper now blocks up behind the ratchet, so the drill will cut fire-box ends of the frame bolts, doing this work from the inside of the fire-box. There are eight of these bolts, and an inch-drill may be used, as it makes no difference whether the holes are drilled straight or not.

The boiler maker gets out the material for the patch. In this case the sheet was ordered for the job and was the right size, but was to be squared up. Measurements are taken from the lines made on the fire-box sheet, and the patch-bolt line made to correspond exactly with it. Along this line, which is scratched on the plate, is laid off the patch bolts. These should be pitched about 1⅞ inches, and stepped off, starting from the center line of the patch. The center line may be a vertical line or a horizontal line, but the vertical line is generally used. If the patch-bolts do not space out pitched 1⅞ inches the dividers should be closed a trifle, and the line stepped over again. This should be repeated until the bolts are spaced exactly. When the proper pitch has been found go over the line again, cross-marking each patch-bolt center, and then center-punch each cross mark. The stay-bolt pitch should be taken from the old sheet, and marked exactly on the plate for the patch. The horizontal and vertical center line of the plate will be used for locating the stay-bolt centers. After stay-bolt centers are center-punched the patch is ready for punching the holes. With a small patch one man can manage the punch and the patch, but with a large patch the helper will be used to work the punch lever or to steady the sheet. The patch-bolt holes are punched 13/16 inch, and the stay-bolt holes are punched 1 inch for 1⅛-inch bolts.

The boiler maker now cuts with a gouge the stay-bolt ends, so the piece of fire-box may be removed. The frame bolts are cut from the fire-box side and the exposed bolts from the outside end, as they have been drilled by the helper. With the outside end of the bolts care should be taken not to injure the threads in the holes. After the stay-bolts are cut loose the cracked portion of the fire-box will be easily removed if the work of ripping has been properly done.

The new sheet is now put up, care being taken that the patch-bolt holes center exactly on the scratched line on the fire-box sheet. This is the test to determine if measurements have been properly made, and if so the patch-bolts will be just where they should be. The patch is held in place by putting long ⅞-inch bolts through the stay-bolt holes and drawing them tight. Care should be taken that the patch doesn't shift its position when the bolts are tightened. The patch in its proper position, the next step is to center the patch-bolt holes with a 13/16-inch bob-punch. The centers made in this manner are where they should be. If the holes are marked off with a scribe or scratch awl and centered with a center punch they will not be true, and when tapped the patch bolts will not have a good bearing. After marking the patch-bolt centers the patch is removed to the drill press, where the machine-shop force countersinks the patchbolt holes.

Should a condition arise where it will be necessary to drill the holes in the fire-box sheet, the drilling should be done while the patch is bolted in place, drilling through the patch-bolt holes in the patch into the fire-box sheet. This insures fair holes; but in such cases holes in the patch should be punched ⅝ inch in diameter. In this case the patch-bolt holes were screw punched into fire-box sheet, a ⅝-inch punch with 11/16-inch die being used.

The frame bolts remaining in the outside sheet of the fire-box have been nicked and broken off. They are centered, and the helper drills a ¾-inch hole through the end. The boiler maker is tapping the patch-bolt holes in the fire-box sheet. Care must be taken that the holes are tapped square with the sheet, and a plate 2 inches by 2 inches, 1 inch thick, through which is a tapped hole the size of the patch bolts, may be used to advantage to aid in keeping the tap straight. The tap is started through the tapped hole in the plate, which keeps it square until sufficient threads have been cut into the fire-box side sheet to support the tap and guide it true.

Before the work had gotten this far the fact that a spindle tap the size wanted, 1⅛ inches, for tapping out the frame stay-bolts could not be obtained had been learned. While this difficulty caused serious consultations it was surmounted, as shown in the full-size drawing of the frame bolts. The machine shop had ample time in which to prepare the bolts and an exceptionally good job was made. The helper had drilled the frame-bolt ends and countersunk the holes in the reinforcement plate, through which the frame bolts pass. These were countersunk, so they would clear the bolts, leaving threads in the outside sheet only. The boiler maker cuts with a gouge (No. 10, Fig. 3) the ends of the frame bolts from the outside sheet, no threads being spoiled in the operation, and taps the holes, using the old threads as a guide, so the holes will be true. The frame bolts are turned in with a pipe wrench, and on account of slight taper at the last threads were easily pulled steam-tight.

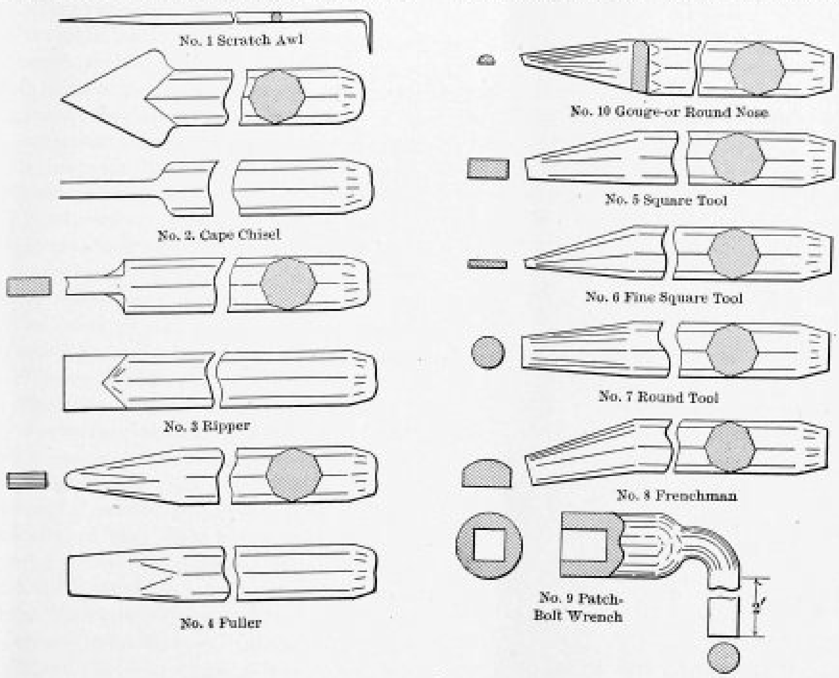


FIG. 3.

The copper gasket, to go between the patch and the old sheet, is now made by the boiler maker, while the helper cleans, with an old file, the portion of the old sheet forming the lap. The patch, with gasket, is put into place, the patch bolts run in and drawn tight. The holes from the patch into the ends of the frame bolts are tapped with a taper and bottom tap, the helper meanwhile tapping the stay-bolt holes from the outside. The stay-bolts and frame-bolt ends are run in, set and cut off. The helper holds on and the boiler maker drives the bolts inside and outside.

The patch bolts are each pulled tight again, using wrench No. 9, Fig. 3, and then the sheet between the patch bolts worked down with the round tool—No. 7, Fig. 3. The patch bolts are pulled up again; the heads are nicked and twisted off. The fuller is used to work down the patch bolts, being worked radially, then gone over with the round tool and cut in with the frenchman—No. 8, Fig. 3. The patch had not been bevel sheared, so it must be chipped before calking. Two chips are taken, then the calking edge is gone over with the fuller—No. 4, Fig. 3—then with the square tool—No. 5, Fig. 3—and the burr cut off with the fine tool—No. 6, Fig. 3. The fire-box sheet will not be cut in this operation if skill is used in calking and chipping.

The machinist had already placed up the expansion plates, and while the boiler was filling with water the grates were replaced. Under 150 pounds hydrostatic test the work was tight, and is to-day, over four years after the work was done, in good condition.

The question of strength of the frame bolts had to be solved, that the pressure upon the boiler might not be cut down. The frame bolts were turned from 2-inch stock, the full diameter remaining at the end of the plug through the fire-box patch. The hole was tapped 1⅛ inches, leaving a net área at the weakest place greater than any of the other bolts in the boiler, and the work was pronounced by those in authority a first-class job in every respect.

The itemized account of the cost of this work is as follows:

BILL OF MATERIAL.		
8 frame bolts, 2 inches diameter, at 2 cents per pound	$1.00	
12 1⅛-inch stay-bolts, finished, at 10 cents each..........	1.20	
40 13/16-inch patch bolts, finished, at 6 cents each......	2.40	
1 sheet 5/16-inch steel, at 2.40 per 100 pounds..........	1.20	
1 sheet 20-pound copper, 8 pounds, at 25 cents per pound	2.00	
Total		$7.80
MACHINE SHOP TIME.		
1 machinist, removing and replacing expansion plates, 5 hours, at 30 cents per hour......................	$1.50	
1 machinist helper, same as above, 5 hours, at 15 cents per hour	.75	
1 machinist, cutting and threading frame bolts, 10 hours, at 30 cents per hour...............................	3.00	
1 machinist helper, countersinking patch-bolt holes, 1 hour, at 15 cents per hour.........................	.15	
1 machinist helper, drilling holes in end of frame-bolts, 4 hours, at 15 cents per hour......................	.60	
Total		6.00
BOILER SHOP TIME.		
1 boiler maker, patching locomotive side sheet, 66 hours, at 35 cents per hour	$23.10	
1 boiler maker's helper, helping on above work, 66 hours, at 17½ cents per hour............................	11.55	
Total		34.65
Total cost of material and labor........................		$48.45

In this cost sheet is not included the expense of bringing the boiler to the shop, nor the loss due to loss of use of the machine.

These items would vary under different conditions and might not amount to anything.

SMOKELESS COMBUSTION OF COAL.

The burning of coal without smoke is a problem which concerns the government directly, because of the advantages of smokeless combustion both in public buildings and on naval vessels. In addition, smoke abatement is a factor in conserving the fuel resources of the United States; hence, as a part of its general investigation of the best methods of utilizing the coals of this country, the United States Geological Survey has made extended tests to determine the conditions necessary for the smokeless combustion of bituminous coal in boiler plants.

The general conclusions of this work, as summed up by Messrs. Randall and Weeks, in a bulletin about to be published on smokeless combustion, are as follows:

Smoke prevention is possible. There are many types of furnaces and stokers that are operated smokelessly.

Credit is to be given to any one kind of apparatus only in so far as the manufacturers require that it shall be so set under boilers that the principles of combustion are respected. The value of this requirement to the average purchaser lies in the fact that he is thus reasonably certain of good installation. A good stoker or furnace poorly set is of less value than a poor stoker or furnace well set. Good installation of furnace equipment is necessary for smoke prevention.

Stokers or furnaces must be set so that combustion will be complete before the gases strike the heating surface of the boiler. When partly burned, gases at a temperature of, say, 2,500 degrees F., strike the tubes of a boiler at, say, 350 degrees F., combustion is necessarily hindered and may be entirely arrested. The length of time required for the gases to pass from the coal to the heating surface probably averages considerably less than one second, a fact which shows that the gases and air must be intimately mixed when large volumes of gas are distilled, as at times of hand-firing, or the gas must be distilled uniformly, as in a mechanical stoker. By adding mixing structures to a mechanical stoker equipment both the amount of air required for combustion and the distance from the grates to the heating surface may be reduced for the same capacity developed. The necessary air supply can also be reduced by increasing the rate of combustion.

No one type of stoker is equally valuable for burning all kinds of coal. The plant which has an equipment properly designed to burn the cheapest coal available will evaporate water at the least cost.

Although hand-fired furnaces can be operated without objectionable smoke, the fireman is so variable a factor that the ultimate solution of the problem depends on the mechanical stoker—in other words, the personal element must be eliminated. There is no hand-fired furnace from which, under average conditions, as good results can be obtained as from many different patterns of mechanical stoker; and of two equipments the one which will require the less attention from the fireman gives the better results. The most economical hand-fired plants are those that approach most nearly to the continuous feed of the mechanical stoker. The small plant is no longer dependent on hand-fired furnaces, as certain types of mechanical stokers can be installed under a guaranty of high economy, with reduction of labor for the fireman. In short, smoke prevention is both possible and economical.

During 1904 to 1906 coals from all parts of the United States were burned at the Government Fuel Testing Plant at St. Louis, in furnaces which were in the main of the same design. Most of the tests were made on a hand-fired furnace under a Heine watertube boiler. The lower row of tubes of the boiler supported a tile roof for the furnace, giving the gas from the coal a travel of about 12 feet before coming into contact with the boiler surface. This furnace is more favorable to complete combustion than those installed in the average plant. A number of coals were burned in this furnace with little or no smoke, but many coals could not be burned without making smoke that would violate a reasonable city ordinance when the boiler was run at or above its normal rated capacity.

In 1907, the steaming section of the St. Louis plant was moved to Norfolk, Va., where subsequent tests of this nature were made. The plant at Norfolk was equipped with two furnaces—one fired by hand and the other by a mechanical stoker.

In the course of the steaming tests some special smoke tests were made, and the influence of various features in smoke production was noted. As the tests were made as far as possible under standard conditions with a minimum variation in boiler-room labor, the results bring out the importance of other factors, such as character of fuel and furnace design. A brief summary of the general conclusion is as follows:

A well-designed and operated furnace will burn many coals without smoke up to a certain number of pounds per hour, the rate varying with different coals, depending on their chemical composition. If more than this amount is burned, the efficiency will decrease and smoke will be made, owing to the lack of furnace capacity to supply air and mix gases.

High volatile matter in the coal gives low efficiency and vice versa. The highest efficiency was obtained when the furnace was run at low capacity. When the furnace was forced the efficiency decreased.

With a hand-fired furnace the best results were obtained when firing was done most frequently with the smallest charge.

Small sizes of coal burned with less smoke than large sizes, but developed lower capacities.

Peat, lignite and sub-bituminous coal burned readily in the type of tile-roofed furnace used, and developed the rated capacity with practically no smoke.

Coals which smoked badly gave efficiencies 3 to 5 percent lower than the coals burning with little smoke.

Briquets were found to be an excellent form for using slack coal in hand-fired plants. They can be burned at a fairly rapid rate of combustion with good efficiency and with practically no smoke. High volatile coals are perhaps as valuable when briquetted as low volatile coals.

A comparison of tests on the same coal, washed and unwashed, showed that under the same conditions the washed coal burned much more rapidly than the raw coal, thus developing high-rated capacities. In the average hand-fired furnace, washed coal burns with lower efficiency and makes more smoke than raw coal. Moreover, washed coal offers a means of running at high capacity, with good efficiency, in a well-designed furnace.

Forced draft did not burn coal any more efficiently than natural draft. It supplied enough air for high rates for combustion, but as the capacity of the boiler increased the efficiency decreased, and the percentage of black smoke increased.

Most coals that do not clinker excessively can be burned with 1 to 5 percent greater efficiency and with a smaller percentage of black smoke on a rocking grate than on a flat grate.

Air admitted freely at firing and for a short period thereafter increases efficiency and reduces smoke.

As the CO in the fuel increases the black smoke increases; the percentage of CO in the flue gas is therefore, in general, a good guide to efficient operation. However, owing to the difficulty of determining this factor, combustion cannot be regulated by it. The simplest guide to good operation is pounds of coal burned per square foot of grate surface per hour.

None of the problems of combustion have received more experimental treatment than the burning of coal in hand-fired furnaces. Hundreds of devices for smokeless combustion have been patented, but almost without exception they have proved failures. This record may be explained by the fact that many of the patentees have been unfamiliar with all the difficulties to be overcome, or have begun at the wrong end Numerous patents cover such processes as causing the waste gases to re-enter the furnace, and schemes for collecting and burning the soot are legion. So many manufacturers who have been looking for some cheap addition to a poorly-constructed furnace to make it smokeless have experienced inevitable failure that the work of educating the public to rid cities of the smoke nuisance has been hard, long and only partly successful.

The total number of steam plants having boilers fired by hand is far greater than the total of plants with mechanical stokers, but if the comparison is based on total horsepower developed the figures show less difference. Particularly is this true in sections of the Central West, where mechanical stokers are generally used at large plants. As a general rule, hand-fired plants do not have proper furnaces, and methods of operation are far from conducive to good combustion. Coal is usually fired in large quantities, and little opportunity is given for the air and gases to mix before the heating surface is reached and combustion is arrested. In all the hand-fired plants visited success in smoke prevention has been obtained chiefly by careful firing. The coal was thrown on often in small quantities; the fire was kept clean, enough ash to prevent the passage of air through the fire never being allowed to collect on the grate; and more air was supplied at firing than after the volatile matter had been distilled. Even with such precautions the plants might have made objectionable smoke at times but for the fact that usually some method was employed for mixing the gases and air before they reached the heating surface.

Some general conclusions from the facts set forth in the bulletin are as follows:

The flame and the distilled gases should not be allowed to come into contact with the boiler surfaces until combustion is complete.

Firebrick furnaces of sufficient length and a continuous, or nearly continuous, supply of coal and air to the fire make it possible to burn most coals efficiently and without smoke.

Coals containing a large percentage of tar and heavy hydrocarbons are difficult to burn without smoke, and require special furnaces and more than ordinary care in firing.

Briquets are suitable for use under power-plant conditions when burned in a reasonably good furnace at the temperatures at which such furnaces are usually operated. In such furnaces briquets generally give better results than the same coal burned raw.

In ordinary boiler furnaces only coals high in fixed carbon can be burned without smoke, except by expert firemen using more than ordinary care in firing.

Combinations of boiler room equipment suitable for nearly all power-plant conditions can be selected, and can be operated without objectionable smoke when reasonable care is exercised.

Of the existing plants some can be remodeled to advantage. Others cannot, but must continue to burn coals high in fixed carbon or to burn other coals with inefficient results, accompanied by more or less annoyance from smoke. In these cases a new, well-designed plant is the only solution of the difficulty.

Large plants are, for obvious reasons, operated more economically than small ones, and the increasing growth of central plants offers a solution of the problem of procuring heat and power at a reasonable price and without annoyance from smoke.

The increasing use of coke from by-product coke plants in sections where soft coal was previously used, the use of gas for domestic purposes, and the purchase of heat from a central plant in business and residence sections all have their influence in making possible a clean and comfortable city.

CALKING AND PATCHING BOILERS.

If a boiler is always repaired just before repairs are needed, it is safe to say that the boiler will never be in need of repairs and that it will never leak or blow a tube. There are many small repairs which can be made by the engineer, which, if made in time, may prevent larger repairs necessitating the shutting down of the plant. The simplest of all repairs is the calking of a leaky rivet. Next comes the calking of a leaky seam. These two repairs should always be made as soon as the leak is discovered. Leakage of this kind, if allowed to continue, will eventually cause the corrosion or wasting of the sheet or plate down or across which the leakage has found its way. When water or steam at the temperature due to high-pressure steam comes in contact with equally hot steel, the conditions are just about right for the speedy union of the oxygen contained in the water and the steel. The result is a body of oxide which is constantly growing deeper and is replacing the solid steel with the worthless and brittle layer of rust. If leakage of this character is permitted to continue indefinitely there can be but one result: the sheet or plate will be corroded completely through, leaving a hole in the boiler. Of course, the leakage must be long-continued in order to perforate a boiler shell in this way.

Every engineer should have two or three calking tools in his kit. To make a calking tool in a hurry, select a very heavy cold chisel (one made from 7/8-inch to 1-inch octagon steel is the best), and forge or grind the end off until it is about 1/4 inch thick. Then round the end of the tool until it is a perfect half-circle ¼ inch in diameter and at least 1 inch wide. Place this tool against the slope of a rivet about 1/16 inch from the shell plate, and strike the tool with a hammer, keeping the tool inclined more or less parallel with the shell of the boiler.

The result of hammering the tool in this manner is to sink a groove in the edge of the rivet, and to drive the metal of the rivet down upon the shell so tightly that nothing can pass out between them. This is all there is to the calking of the longest seam or joint in a boiler. If the tool is moved along as the hammering proceeds there will be a shallow, rounded channel formed entirely around the rivet or across the sheet, effectually closing the opening between the sheets against leakage.

When a leaky rivet or seam is found, instead of letting it go until a boiler maker can be brought to the scene, the engineer should take a hammer and calking tool and stop the leak, which can be done in a few minutes. Caution should be used in calking a leak if the boiler is under steam. It may be considered safe to calk a boiler under steam, but the writer does not consider it at all advisable and never does it in his own practice. Calking a seam against 150 pounds boiler pressure would never be done by the writer unless it were absolutely necessary, and that is seldom the case if leaks be taken in hand when they first develop. If leaks must be calked when the boiler is under steam, then the steam pressure should be lowered at least one-third before attempting to calk anything more important than a single rivet, which, were it to lose its head during the calking operation, when under pressure, could not result in a serious accident. Calking under cold-water pressure, in new boilers, is sometimes practiced, but even that, when at or above working pressure, does not seem desirable to the writer.

Repairs which necessitate the putting on of a soft patch can sometimes be handled by the engineer with good results. A soft patch is of no use when it must be located where the fire will reach it or intense heat will play against it, and where there is no opportunity for water to get at the other side of the patch. When it is required to close a hole or a crack located where the fire cannot burn the metal, then good results will be obtained from the use of a patch bolted on. To put on a patch of this character in such a manner that no calking will be necessary it should be fitted as closely as possible by heating and forging. The holes may then be drilled and those in the shell beneath the patch tapped, or drilled large, and through-bolts used. Tap-bolts are preferable, for jamb-nuts may be put on the bolts inside the shell and leakage through bolt-holes prevented.

After the patch has been bedded and fitted, coat the inside of the patch and the outside of shell, where the patch is to come, with Portland cement, mixed with sufficient water to make it into a paste which will spread, but which will not run when the sheet is turned upside down. Wet the metal before applying the cement paste, and make sure that the surfaces are clean and free from grease especially. When the patch is in place and the cement is between the surfaces, the bolts may be inserted and screwed down to within ⅛ inch or so of where they will be when fully screwed home. Then let the joint stand about one hour, depending on the cement used. It should stand until the cement just begins to set and not after. This may be determined by testing the protruding fringe of cement around the patch. Just as the cement begins to refuse to flow readily, screw the bolts tight, putting an even strain on each, and let the job stand ten hours—twenty-four hours if possible —but ten hours will do. The boiler may then be fired without any sign of leakage. The cement hardens as much in a few hours under steam heat and pressure as in twenty-eight days in the open air.—*James Francis in the Electrical World.*

Do not attempt to work steel boiler plate at a blue heat. It is hard work and injures the plate.

The Best Method of Cleaning Ash-Pans in Compliance with the Inter-State Commerce Commission Law.*

BY E. C. HAUSE.

There are quite a number of devices for cleaning ash-pans, and superintendents of motive power and master mechanics are giving this matter some attention as to which is the best and cheapest device that can be put in operation as specified by the law. I noticed a sketch in the May issue of THE BOILER MAKER, on page 131, of two styles of self-dumping ash-pans that are in use on the Lake Shore & Michigan Southern. That is a very good device, but it can be simplified. Instead of making the bottom dump the clinkers, that could be so arranged to make the bottom of the pans with slide bottom. The Seaboard Air Line System has adopted the slide-bottom ash-pan as a standard on all their engines with the hopper pans, and we are getting excellent results from same. We have a cast iron frame for the bottom of the pan with two sliding doors, which are coupled together. The sliding doors have two cast iron lugs on the bottom, and they are operated by a tumbling shaft made of 2-inch round iron, which is bolted to the frame with a square on the outside for a socket wrench, and the sliding bottoms are connected together, so as when you throw the lock clamp up both slides open at the same time. We have several on our engines which have been in operation for seven or eight months, and which have not given us any trouble. This is a very economical device, and it can be applied to any engine for about $15.

We also have our passenger engines on the fourth division of the Seaboard Air Line equipped with a blower pipe in the front section of the ash-pan, which I believe is the cheapest and best device that I have seen for cleaning ash-pans. We tap a hole in the boiler head on the left-hand side below the waterline for a 1¼-inch globe valve, and run a 1¼-inch pipe down through the deck and reduce it to 1 inch in the pan. This pipe is fastened in the center of the pan with a clamp. We extend the pipe down the slope of the hopper pan about 6 inches, and have a shield made of a piece of ⅛-inch tank steel fastened to the frame behind the main pedestal, just far enough back to clear the eccentric and just far enough ahead to allow the front damper to open. The object of this shield is to protect the machinery from the clinkers blown out of the pan. This is the cheapest and best device I have seen, as it is convenient and handy at all times, and can be used with perfect safety. When you open the valve the water will put out what live fire there may be in the pan and the steam and water blows the pan clean. You can see there is no chance to set fire to anything. We have had this blower in use on the fourth division on our passenger engines for over a year, and they have given excellent service. This blower can be applied for about $5. The blower was found to be of great advantage to us on our fast trains when we were using bad coal, as the fireman could always keep his pan clean without any delay, and it can be worked at any time from the cab with safety.

We are also trying another device for cleaning the shallow ash-pans on the deep fire-boxes. This is operated with a globe valve. Put a 1¼-inch globe valve in the boiler below the waterline, run 1¼-inch pipe to the front end of the pan; here we connect it to an oblong casting made in the shape of a drip-pan casting for gage cocks. This is about 2 inches thick and about 6 inches wide.

The casting with the 2-inch opening is extended about 5 inches in the front end of the pan, and is bolted to the bottom of the pan. The openings in the casting are about ⅞ by 2½ inches, and they are tapered so as to make the steam spread across the pan. The only defect that I see to this is that it does not clean the pan at the front end, but from about 14

* Read before the International Railway General Foremen's Association, June, 1909.

inches from the front damper back, it cleans it perfectly. We are just experimenting with this one now, but with the others we will change them by widening the openings and setting it back out of the pans, and I think we will get results on the class of engines with deep fire-boxes and shallow pans. This can be applied very cheaply. The two oblong holes are made tapering so as to throw the steam and water down to the bottom of the pan. This device can be worked from the cab the same as the other blower on the passenger engine that I spoke of before.

LAYOUT OF INTERSECTING CONES.

BY I. R. M.

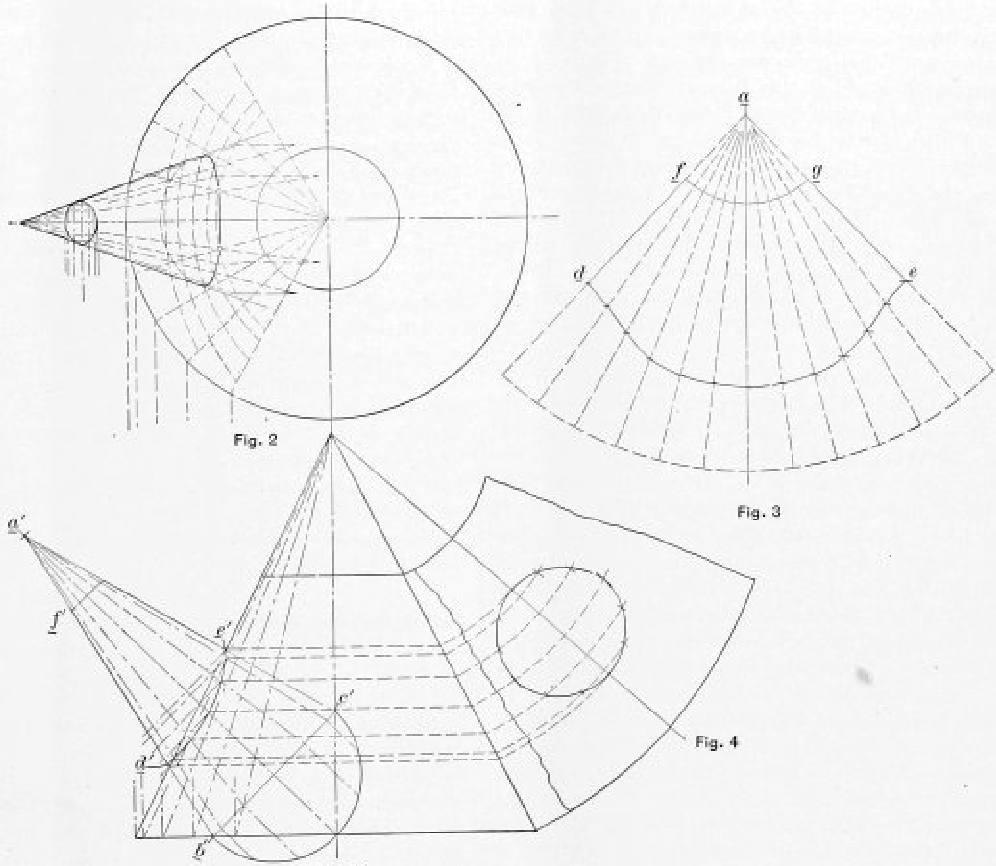
In Fig. 1 is shown the intersection of two cones, the axis of the smaller cone being at an angle of 45 degrees to the larger cone. To develop the pattern, first draw the plan and side elevation as shown in Figs. 1 and 2. Divide the smaller cone into any number of equal spaces (in this case twelve have been used), and draw lines radial from its apex. Reproduce these same lines on the plan by projecting lines from the side elevation.

On that portion of the plan, Fig. 1, where the smaller cone intersects, divide off a number of equal spaces on each side of the center line of the smaller cone. Project these lines, cutting the circumference of the plan, to the side elevation, and erect radial lines to the apex of the larger cone. Lay off points on the division lines made on the plan view equal to the distance from the center line, Fig. 1, to the intersecting points made by the radial lines of the two cones. Through these points construct the irregular curves as shown.

Through the intersecting points of these irregular curves with the radial lines, Fig. 2, draw the irregular curve representing the intersection of the smaller cone with the larger cone, as it appears from a plan view. From these intersecting points project parallels intersecting the same radial lines of the small cone, Fig. 1. Through the intersecting points so made, draw the irregular curve representing the intersection of the two cones as they appear from a side elevation.

To develop the pattern of the smaller cone, Fig. 3, draw an arc having a radius equal to the line *a' b'*, Fig. 1, the length *b c* of the arc should be equal to the circumference of a circle having a diameter equal to the line *b' c'*, Fig. 1. Divide the arc *b c*, Fig. 3, into the same number of spaces as the cone in Fig. 1 is divided, through which division points draw radial lines to the point *a*. With a pair of dividers lay off points on these radial lines, from the line *b c*, equal to the distance on the same radial lines in Fig. 1, from the line *b' c'* at the point *b'* to the intersection points made in the hypotenuse of the small cone by projecting lines at right angles to the axis of the small cone from the intersection points made by the irregular cone *d' e'* with the radial lines.

Through these points draw the irregular curve *d e*. From



PLAN, ELEVATION AND DEVELOPMENT OF INTERSECTING CONES.

the point *a*, draw another arc, *f g*, having a radius equal to the line *a' f'*, Fig. 1. Connect the arc *f g*, and the irregular curve *d e* by the solid lines *f d* and *g e*, thereby finishing the development of the small cone.

To develop the large cone, Fig. 4, draw arcs in a similar way, the length of the arcs being equal to the circumference of the upper and lower base of the cone, and having a radius equal to the hypotenuse of the cone.

To develop the opening for the intersection of the small cone, draw a series of arcs through the center of the sheet, their radius being equal to the distance from the apex of the large cone, Fig. 1, to points on the hypotenuse of the cone by projecting parallel lines from the points of intersection of the irregular curve *d e*, with the radial lines as shown.

On the arcs so drawn, lay off points on each side of the center line equal to the length of the curves representing the same arcs in the plan view, Fig. 2. Through these points draw the irregular curve forming the opening for the intersection of the small cone, thus finishing the development of the cones.

Renewing the Crown Sheet and Back Tube Sheet in a Large, Narrow Fire-Box Locomotive Boiler.

BY HENRY MELLON.

The crown sheet had come down, and it also jammed down some of the tube holes in the middle of the back tube sheet of the upper four rows. These four rows jammed down and also jammed the bridges of the tube sheet down quite flat, making it necessary to put in a new crown sheet and a new back tube sheet. The job was done at the Rhode Island Locomotive Works, at Providence, R. I., in 1898. The boiler was in the engine frame with no stripping, and the engine sat over a pit.

First, a piece was cut out in the back tube sheet, right over the belly center braces, some 6 inches square, by cutting from bridge to bridge until the piece was cut out. Then all the 2-inch tubes were taken out of this hole and out of the door holes and thrown on the shop floor. I had them split at the front end, and then from the fire-box end I drove them through to the front end 1 inch, and the man at the front end drove them back to me as I guided them out of the hole which I had cut in the fire-box end. It was an easy and quick way.

A man was put to work ratcheting out the stay-bolts on the saddle sheet. He cut the heads off and drilled in some three-fourths of an inch, while I with a helper cut off the belly-brace rivets in the fire-box end and all the rivet heads off on the tube sheet in the fire-box.

The crown sheet was one plate by itself with a flange looking down for about 6 inches. The rivets on the two seams of the flange of the crown shell were cut out, and the sling stays from the crown bars to the top jacket sheet taken out, and then the crown sheet was raised up and two rods of 5/8-inch round iron were placed crossways of the fire-box, and the crown sheet rested on those two 5/8-inch rods. They acted as rolls. Then the tube sheet was knocked out at one corner, and lowered down into the pit and then taken to the boiler shop and a new one made, with the tube holes and the rivet holes put in the new one and the flange chipped bevel for a calking edge. Two bars of iron, some 6 feet long by 1 1/4 inches square, were then rolled to a 27-inch radius, as the boiler shell was 54 inches diameter, and placed in the shell of the boiler, some 54 inches apart. The crown sheet was rolled on the two rods of 5/8-inch round iron out on those two 1 1/4-inch square bars, with one flange looking up and the other flange looking down. Those two 1 1/4-inch bars were to clear the heads of the rivets when the crown sheet was being turned in the shell of the boiler. To make it turn easily I put a block and fall down through the dome and fixed it to the crown sheet. After the crown sheet was on its flange, standing edgeways, with all the crown bars still on the crown sheet, it was slid out into the fire-box and down into the pit and out onto the floor. The crown bars were then taken off and the crown sheet carried to the boiler shop, where a new one was made.

When the new one was made it was placed alongside the old one with the four flanges looking up, and any kink or bend that was in the flanges of old crown sheet was put in the flanges of the new crown sheet. This was done after all rivet and crown-bar holes were put in and after the edge was chipped for calking. Then the new crown sheet was put in place in the same manner as the old one was taken out. While the crown sheet was held up on the 5/8-inch iron rolls, the tube sheet was put in and bolted to the side sheets. Starting down in the bottom of one leg of the tube sheet the rivets on the flange of the tube sheet were driven all around the flange. A wedge bar, some 20 pounds, was used to hold on to the rivets in the leg, and wherever a sledge could not be used. A 20-pound sledge was used on the top of the tube sheet and the corners. Next the rivets in the two seams of the crown sheet were driven, holding on to the rivets with the side of a sledge where the face could not be used. Then the rivets in the belly braces were driven, and then the holes for the same-sized stay-bolts in the saddle sheet tapped out; that is, where the old ones were not damaged as the work had been chipped. Finally it was calked with a fuller and a square tool, finishing it with a fine beveled tool.

As all the work was riveted on the inside and calked on the inside it made an excellent tight job, but when the two corners at the bottom of the mud-ring came to be riveted it was necessary to heat them with a blow lamp or some other way. In doing this it is desirable to get at least a dark red, and hold a fuller in the corner, and hit it with an 8-pound hammer. Also heat the top four corners of the crown sheet on the tube and door sheet, and hammer those four corners on the fire-side and on the water-side, and calk the job on the water-side as far as can be done.

As the side sheets were not disturbed the crown bars fitted without change and were put on, starting with the one over the door, and putting the rest in one at a time finished. After these came the sling braces and the stay-bolts on the saddle sheet, and finally the tubes. Then the boiler was filled with water and tested.

In a job of this kind, if there are any little leaks calk them so as to stop them. If it is a calked seam that leaks turn the fine tool over and hit it, and that will cause a splitting and stop a leak. If it is a rivet, use a blunt fuller and a rivet calking tool, and that will stop the rivet. If it is a tube, roll it and that will stop the leak. It is best to fill the leg up with water so as to try the bottom hoop corners before the tubes are put in, and if any rivet should leak badly, then cut it out and put in a new one. There is no need of any patch bolts in this job. The entire job can be hot riveted, and a lot depends on having good, heavy holding-on tools, and to be sure and hold on to only one rivet head at a time. The boss of the job should look after all this.

Self-Dumping Ash-Pan to Conform with Requirements of Inter-State Commerce Commission.*

BY W. E. DUNKERLEY.

Relative to the best design for a self-dumping ash-pan to conform with the requirements of the Inter-State Commerce Commission, I wish to advise that our system has a self-dumping ash-pan, and we have been using same for the last seven or eight years on our high-pressure boilers. These boilers all have the high fire-box, and there is plenty of room for the design of ash-pan which they have. These ash-pans are made in a hopper shape, with slides on the bottom, which are operated from a lever in the cab. We formerly had these pans equipped with an air cylinder, but the air cylinder could not always be relied on, on account of same getting dry, and the ash-pan would warp out of line with the cylinder, thereby making it expensive to keep this kind of an ash-pan in repair. We have since done away with this style of pan, and have applied, as I have above stated, one which operates with a lever in the cab. These ash-pans are made out of cast iron.

The ash-pan slide guides on these pans are cored out and arranged so that steam is connected to same and the guides themselves act as a heater for cold weather; this to prevent them from freezing up.

We have had very good success with this design of an ash-

* Read before the International Railway General Foremen's Association, June, 1909.

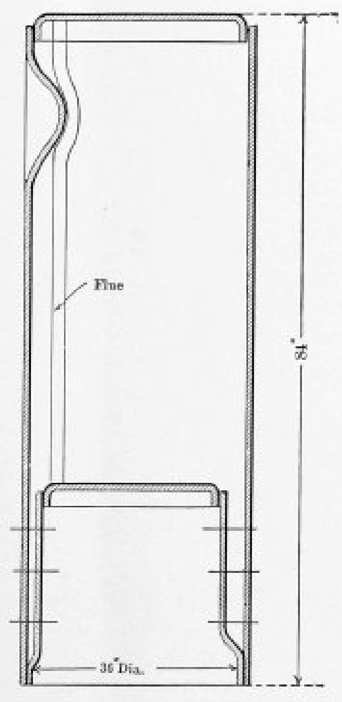
pan. The slides, guides and hoppers of the pan are made of cast iron, the upper portion which keys onto the mud-ring is made out of sheet iron.

Our low-pressure power, which have the fire-boxes hung between the frames and which are equipped with hoe-pan, do not conform with the requirements of the Inter-State Commerce Commission. These pans we will have to change. We have not designed a standard for these engines as yet, but I have recomended a pan for this class of power. This pan is to be made out of cast iron and keyed onto the mud-ring. The side bars will have to be raised 10 inches in the fire-box, from the bottom of the mud-ring, which will take away some of the heating surface out of the fire-box, but I do not see any other way out of it. This can be operated from the cab with a lever.

STRAIGHTENING THE SHELL OF A VERTICAL BOILER.

BY JOHN J. M'GRATH.

I was running a small repair business in the city of Pittsburg, Pa., about five years ago, doing general repair work, and as I was looking around one day I got into a scrap-yard, and there I saw a vertical boiler 36 inches diameter by 84 inches high. It looked apparently as good as new, with the exception of a large dent in the top of the shell. The boiler had been



SECTION OF BOILER SHOWING DAMAGED PLATE AND TUBES.

in a fire at the plant of the John Carlin Foundry & Machine Company, and some heavy beams fell and hit it while it was hot. The blow had made quite a large dent on one side of the shell, causing the boiler to be scrapped. I went to the foreman of the yard and asked him what he was going to do with the boiler. He said he was going to cut it up, as all the boiler makers and dealers in the city had seen it, and said they couldn't do anything with it. I went to the office and asked the owner of the yard what he wanted for the boiler. He said 75 cents per 100 pounds. I told him to load it up and send it to my shop.

I looked it over carefully, and decided to repair it by means of hydraulic pressure; but before I applied the pressure I had been informed by some of the first-class boiler makers in the Smoky City that I was up against it, and that there was no way to repair that boiler and make anything out of it, and the best thing I could do was to sell it again for scrap. There were several tubes bent where the sheet had hit them, so the first thing was to take them out and plug the holes and get everything in the line of pipe holes stopped up.

I applied 200 pounds pressure cold water with a hand-pump, and had a man hold the pressure at that point. I got a 25-pound sledge and started to hammer around the edges of the sharp dent, and it started out. It started slowly at first, but after it came out about 3 inches it seemed as though the pressure alone would almost drive it out. I kept hammering and pumping, and from the time I started to work on the boiler with one man as a helper it took me just 13 hours taking out seven tubes and replacing them, and finally fixing up the boiler so you could hardly tell it was ever damaged after it had been painted.

The boiler, all told, cost me $23.00. I advertised it and got a buyer four days after I had it finished at the price of $100, which gave me a profit of $77.00. I have since applied the same idea on two other boilers with the same results. I can recommend the application very highly, except on an old boiler that is too weak. In that case you will have to regulate the pressure and also the size of the hammer you were going to use.

Cutting Threads on Steel Tubes.

Steel tubes have now so nearly replaced those of wrought iron that those working them to-day may not realize that not very long ago it was found difficult to cut threads on them. The procedure found effective with wrought iron was decidedly inefficient with steel. Some one discovered, however, that if the cutting tool were so shaped or disposed that the edge actually performing the cutting inclined about 15 degrees back from a prolonged radius drawn through the point of attack, then steel could be effectively cut. With wrought iron tubing a cutting edge that was simply a radial plane prolonged was effective. One explanation for the difference is that wrought iron contains more or less cinder imbedded in the metallic body, and the resistance to a cutting tool afforded by a material thus honeycombed could not be so great as that of compact, homogeneous steel. It may be added that this variation of 15 degrees produces a tool that is also effective with wrought iron.

To accomplish in practice this relation between the cutting edge and the work, two courses are open to the machinist. If his tool is horizontally arranged in the tool holder he may adjust it so that the actual cutting will be done at the end of a horizontal diameter, and by notching it from the upper edge may obtain the necessary form, or he may raise his tool holder until the upper edge is 15 degrees (with the work) above the horizontal diameter and grind the end of the tool away somewhat so as to permit the cutting edge to come in contact with the work, and a little more to provide proper clearance. Following either procedure, the cutting operation is performed with a tool which recedes 15 degrees from direct opposition to the movement of the work. This principle of using a wedge form of tool for the threading of steel pipe has application to the machining of steel in general.—*The Iron Age.*

The annual convention of the American Boiler Manufacturers' Association of the United States and Canada will be held in Detroit, Mich., Aug. 10, 11 and 12. Important matters relating to the welfare of the organization as well as subjects of a technical and trade nature will be brought up for discussion. Every member of the association should make it a point to attend.

LAYOUT OF A BREECHING FOR A SCOTCH BOILER

BY S. W. PERRY.

Fig. 1 is a front view and Fig. 2 a side view of the breeching or uptake for a three-furnace Scotch marine boiler, 12 feet long by 12 feet 6 inches diameter. The top view or plan of the breeching is shown in Fig. 3, and in this the lines for getting the true lengths of the sides of the triangles are shown. Since this is an irregular-shaped piece, it is necessary to lay it out by triangulation. The lengths of the lines, shown in Fig.

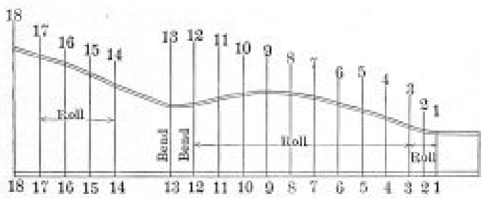
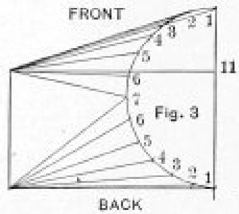
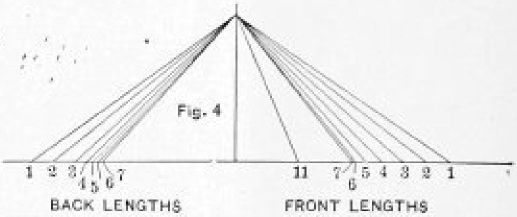


Fig. 5





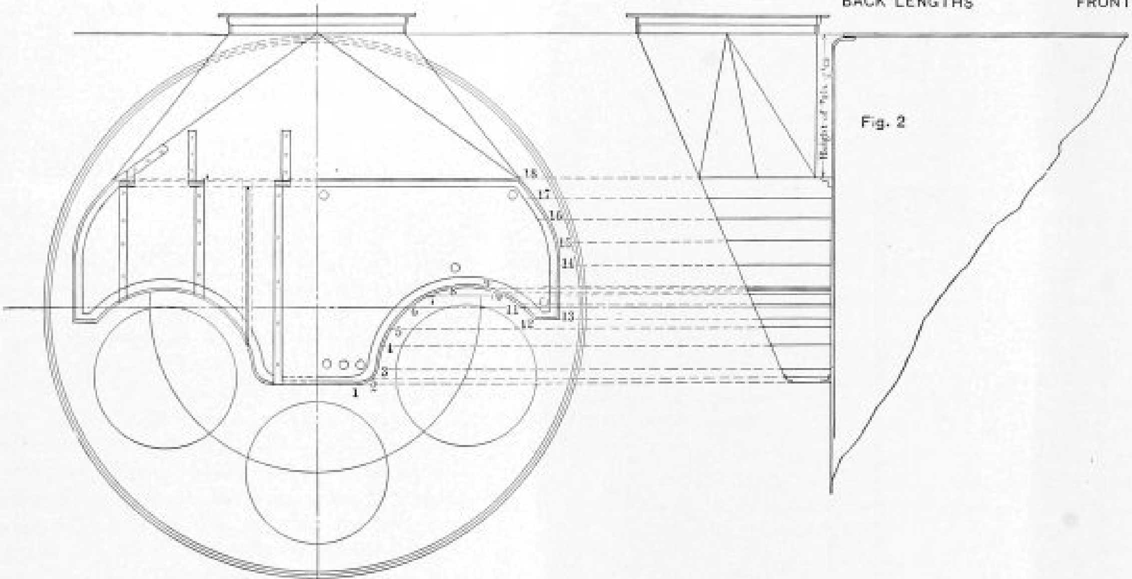


Fig. 1

3, form one side of the triangles, and the height of the breeching, as shown in Fig. 2, forms the second side. The third side of the triangles shows the true lengths of the lines to be used in the pattern. These are shown in Fig. 4. Transferring these lines from Fig. 4 to their proper place in the stretch-out, we get the layout, shown in Fig. 6, for the front plate. All the lines in this figure are taken from the side of Fig. 4, marked "Front Lengths." The back plate is laid out similarly, taking the lengths of the lines marked "Back Lengths" in Fig. 4. This layout is shown in Fig. 7.

The layout of the box for the furnaces is shown in Fig. 5. This shows the layout of only one-half of the box, since both halves are alike, and when one is laid out the other can be marked from it. This part of the work is very simple, and the diagram needs no further explanation.

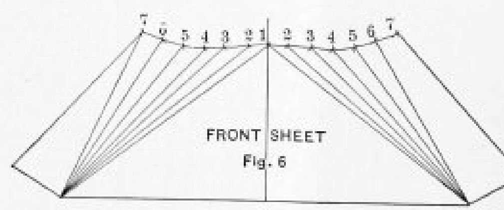


Fig. 6

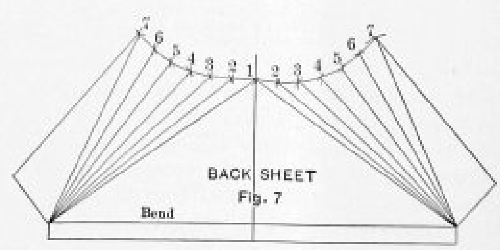


Fig. 7

All State and city boiler inspectors should plan to be in Detroit, Mich., Aug. 10, 11 and 12. A meeting has been called by Mr. J. C. McCabe, city boiler inspector of Detroit, for the purpose of forming a national organization of State and municipal boiler inspectors. This is a worthy movement towards securing uniform boiler construction and inspection throughout the United States, and should be heartily supported by every boiler inspector in the country.

REPAIRING A MARINE BOILER FURNACE.

BY JAMES CROMBIE.

A boat was towed into harbor not long ago on account of the failure of her boiler. She had one boiler, Scotch marine type, about 10 feet 6 inches diameter, with two furnaces. The flange of the port furnace at the center side had cracked. The crack started at the top corner, at the saddle plate, and extended downwards about 18 inches. This fracture occurred while the boiler was under 160 pounds steam, and the engineer and fireman on watch were severely scalded by the escaping steam and water.

We were called on to repair the boiler, and found that it would require a patch about 24 inches by 18 inches by 9/16 inch thick. The rivets in the flange would have to be cut out and also a piece of the furnace plate, and the patch made to catch the side of the fire-box or combustion chamber (double riveted seam), and also take several rivets on the saddle, then go down and take a single-riveted seam inside the furnace, as illustrated in the drawing. All the work would have to be done by hand, as the job was situated in an inconvenient place.

A man was sent down to make a hoop-iron template of the required patch, and then come to the shop and flange the patch. Another boiler maker was sent down with a hammer, flat and cape-chisels and a ratchet drill, to cut out all rivets in way of the new piece and to cut out the piece of damaged plate. After the piece was cut out the plate was scarfed or thinned down by chipping with flat chisels at each lap, so that the new plate would lie close.

The patch in the meantime was flanged by hand, the plate being heated and turned down by sledge hammers over the edge of the flange block, this flange to take the double-riveted seam. The circular part to go inside the furnace was then flanged over a suitable cast-iron block.

The patch was then taken on board and tried in place. Several holes were marked down the side flange. It was then taken to the shop; these tack holes drilled in the radial drill; the plate heated all over and run down to the job and quickly bolted up and hammered as closely as possible. Owing to the awkward shape of the patch it had to be heated again and swedged close at the top corner, the rivet boy's fire, which had been taken aboard in the meantime, supplying the necessary heat. All holes were then marked in the patch, and it was taken to the shop and drilled, and all holes countersunk for riveting. It was again heated all over and bolted into place, and the holes drilled through the furnace with a ratchet drill, all the holes being for ⅞-inch rivets. The patch was then taken off and all surfaces cleaned, and then it was bolted up ready for riveting.

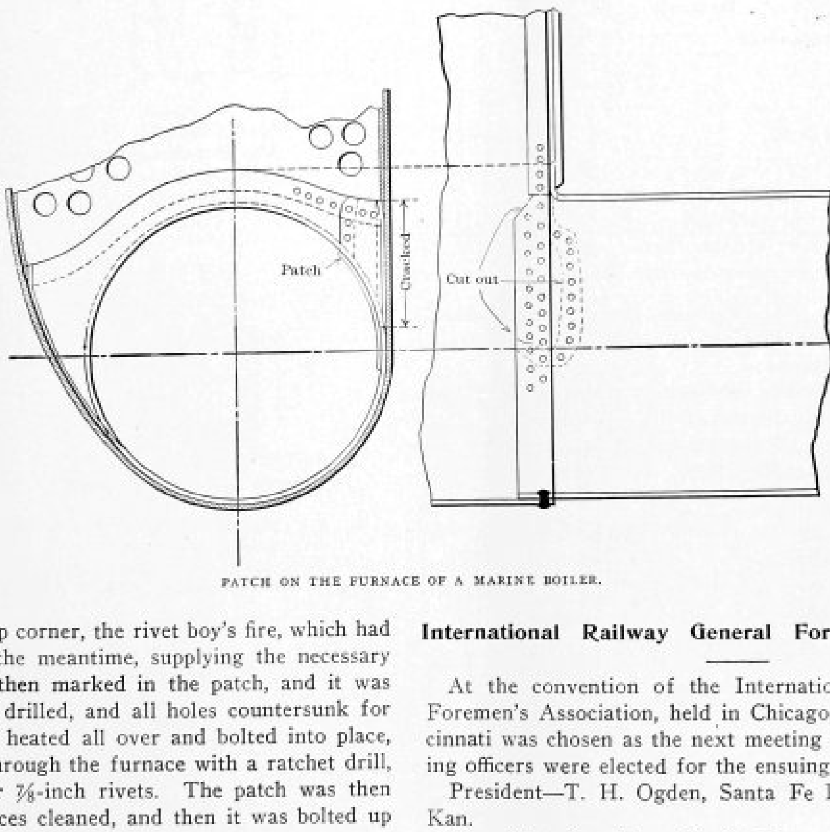
The rivets were heated and handed in at the manhole door to another boy; this boy passing them to the helper, who was holding on the rivets. The rivets in the double seam or water space between the two fire-boxes were held on with a water-space hammer, all other rivets being held on with a regular holding-on hammer. Two boiler makers were inside the furnace doing the riveting, but several of the rivets had to be driven single handed. None of the rivets when driven were finished up, but the plate at the next hole was hammered, and the second rivet back was then hammered and finished off, thus making a good, hard joint without any slack rivets or soft spots.

The plate was then calked, using a flat calking tool with the sharp edges ground off to prevent cutting the plate. (The round-faced calking tool does not calk the plate properly, but rather, acting as a wedge, tends to force the plates apart.) After calking, the boiler was filled up and the furnace mountings replaced. Steam was then raised; the boiler inspector standing by to see that all was right. After steam was up and the safety valve blowing off, the inspector pulled the furnace door wide open, allowing the cold air to rush in and strike the patch, his intention being to try and cause it to leak. It was tight and pronounced O. K.

TIME AND MATERIAL FOR THE JOB.

Boiler maker, cutting out, about 15 hours.
Flanging piece, fitting on and drilling, boiler makers, 17 hours.
Helper, 14 hours, boy 10 hours.
Riveting, two boiler makers, one helper and two boys, 5 hours each.
Calking, filling up boiler, replacing bridge wall and furnace mountings, boiler maker 15 hours, helper 15 hours, boy 5 hours.

Total time on job:	
Boiler maker, 57 hours, at 25 cents per hour	$14.25
Helper, 34 hours, at 18 cents per hour	6.12
Boy, 25 hours, at 10 cents per hour	2.50
Material:	
Plate, 24 inches x 18 inches x 9/16 = 69 pounds, at 4 cents per pound	2.76
35 rivets, ⅞ inch diameter = 24 pounds, at 5 cents per pound	1.20
	$26.83



PATCH ON THE FURNACE OF A MARINE BOILER.

International Railway General Foremen's Association.

At the convention of the International Railway General Foremen's Association, held in Chicago, June 1-5, 1909, Cincinnati was chosen as the next meeting place, and the following officers were elected for the ensuing year:

President—T. H. Ogden, Santa Fe Railroad, Dodge City, Kan.

First Vice-President—C. H. Voges, Big Four Railroad, Belfontaine, Ohio.

Second Vice-President—T. F. Griffin, Big Four Railroad, Indianapolis, Ind.

Third Vice-President—W. F. Hall, C. & N. W. R. R., Escanaba, Mich.

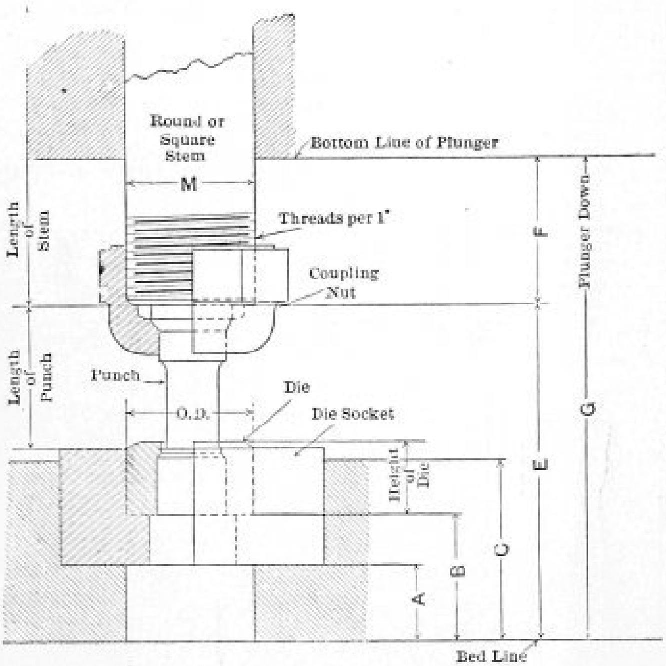
Fourth Vice-President—J. A. Boyden, E. R. R., Cleveland, Ohio.

Secretary and Treasurer—L. H. Bryan, D. & I. R. R., Two Harbors, Minn.

Members of Executive Committee—H. D. Kelley, C. & N. W. R. R., Chicago, Ill.; T. J. Finerty, I. & G. N. R. R., Spring, Tex.

PROPOSED I. M. B. M. A. STANDARD PUNCHES, DIES AND COUPLINGS.*

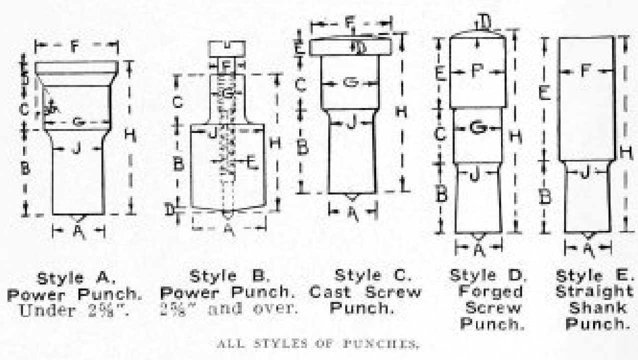
First, we will take up the matter of punches, and will say that we have in our possession a table showing the dimensions of all standards introduced and made by the various manufacturers. Before delving too deeply into the subject, we desire to make known the fact that we have not accepted any of the standards now in use, but have decided upon a new system



PROPOSED STANDARD CLASS "A" PUNCHES.

and a new standard. We now present this system and detailed dimensions of punches, dies and couplings for consideration, for the following reasons:

First. Because it is the only system which, with one stem and one coupling, with the aid of sleeves, will render it possible to punch almost all holes required in a boiler or plate shop without changing the stem. With this system, holes

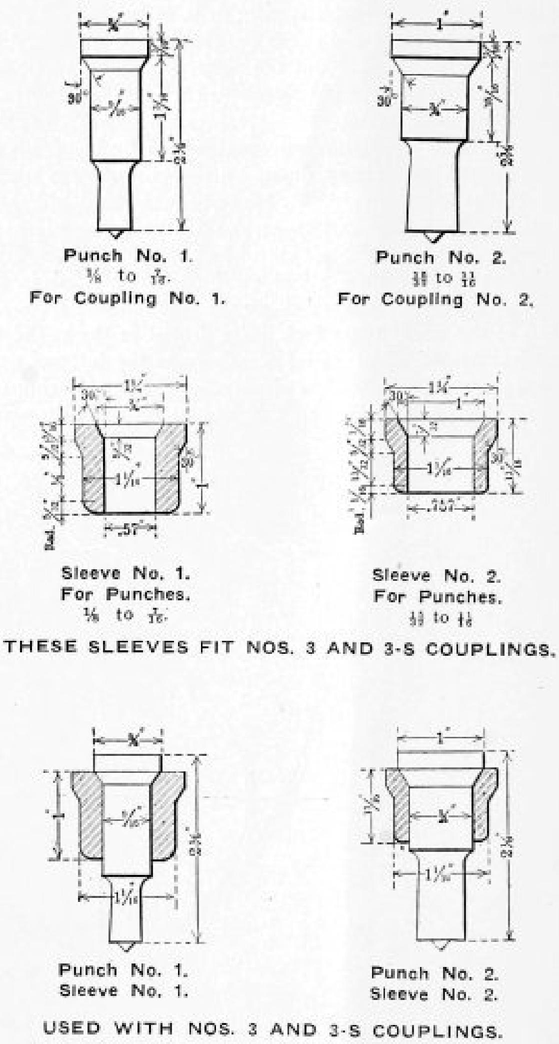


ALL STYLES OF PUNCHES.

from ⅛ inch diameter to 1 15/16 inches diameter can be punched.

Second. The sleeve renders it possible to make small punches out of the smaller-sized steel.

Third. We believe that punches 2⅝ inches in diameter and larger should not be made for use with a coupling nut, and are of the opinion that when this size is reached the nut should be entirely dispensed with, not only saving the cost of a nut, but by using style "B" punch it can be made out of much smaller-size steel, besides the fact that it takes up less room and holes can be punched much closer to the flange.



STYLE "A" PUNCHES AND SYSTEM OF SLEEVES.

Fourth. We believe that when a punch is broken it should be scrapped and no attempt should be made to use it up by a series of steel blocks and extra long couplings. The most complete system, in our judgment, is the one having the least parts and of the best mechanical construction; hence we produce herewith not only detailed drawings of punches which we recommend, but also a table giving dimensions, which we hope will be found useful to those interested in punches.

Power punches 2 9/16 inches in diameter and smaller shall be known as style "A." All punches above this size shall be known as style "B." By this system of lettering our punches, we believe much confusion will be eliminated.

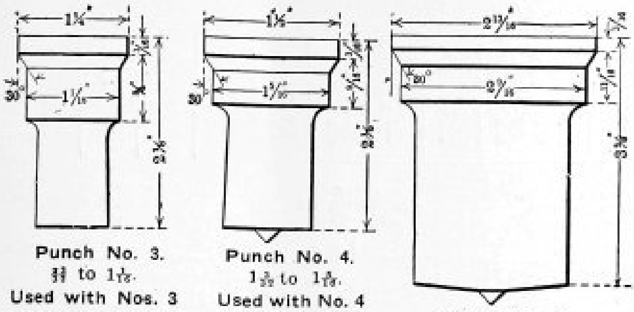
STYLE "B" PUNCHES.

Dimensions given are standard for all sizes of punches regardless of the diameter or shape of the punching portion.

The spring used is 3 inches long, 19/32 inch outside diameter, and made of .047-inch diameter of wire.

How to order punches by wire. Suppose we desired twenty-five 13/16-inch standard punches, we would order as follows:

* Editor's Note.—This article is an abstract of a report presented before The International Master Boiler Makers' Association at Louisville, Ky., April, 1909, by the committee on standard boiler-shop tools, machinery and equipment. It should be understood that the standards herein proposed are simply the recommendations of the committee and have not been adopted by the association. The subject of standard punches, dies and couplings is to be carefully considered during the coming year by boiler makers and manufacturers of the tools with a view to arriving at a satisfactory standard. The Boiler Maker will gladly publish any communications of importance relating to this subject.

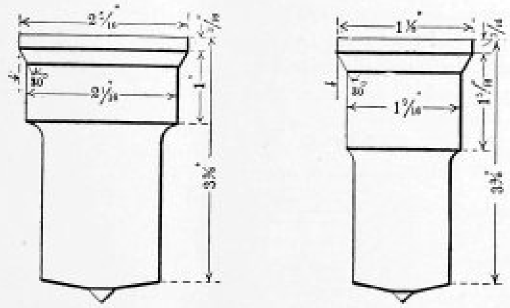


Punch No. 3. 13/16 to 1 1/16. Used with Nos. 3 and 3-S Couplings.

Punch No. 4. 1 3/32 to 1 5/16. Used with No. 4 Coupling.

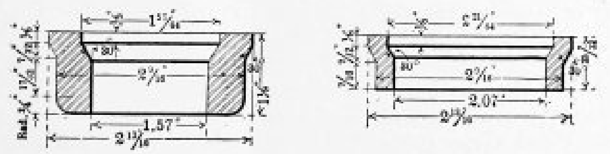
Punch No. 7 2 1/8 to 2 9/16. Used with No. 7 Coupling.

ABOVE PUNCHES USED WITHOUT SLEEVES.



Punch No. 5. 1 1/16 to 1 9/16. Used with Coupling No. 5 or Coupling No. 7 with Sleeve No. 5.

Punch No. 6. 1 5/8 to 2 1/16. Used in Coupling No. 6 or Coupling No. 7 with Sleeve No. 6.



Sleeve No. 5. For Punches. 1 1/16 to 1 9/16. Used with No. 7 Coupling.

Sleeve No. 6. For Punches. 1 5/8 to 2 1/16. Used with No. 7 Coupling.

STYLE "A" PUNCHES AND SYSTEM OF SLEEVES.

Express twenty-five thirteen-sixteenths International Master Boiler Makers' "A" punches.

Style "B" punch, while shown as round, is well adapted to all irregular shapes, such as hand holes, etc.

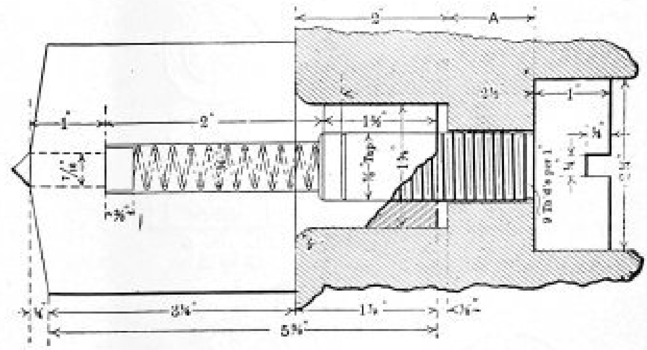
PROPOSED INTERNATIONAL STANDARD STYLE "A" AND "B" PUNCHES.

No.	A	B	C	D	E	F	G	H
1	1/8 to 7/16	3/4	11/32	5/32	3/16	3/4	9/16	2 1/8
2	15/32 to 11/16	1	29/32	7/32	3/16	1	3/4	2 1/8
3	23/32 to 1 1/16	1 3/16	19/32	5/32	3/16	1 1/4	1 1/16	2 1/8
4	1 3/32 to 1 5/16	1 3/8	13/32	5/32	3/16	1 1/2	1 5/16	2 1/8
5	1 1/16 to 1 9/16	1 7/8	1 1/32	9/32	9/16	1 7/8	1 9/16	3 3/8
6	1 5/8 to 2 1/16	2 3/16	25/32	7/32	3/16	2 5/16	2 1/16	3 3/8
7	2 1/8 to 2 9/16	2 1/2	29/64	15/64	5/16	2 13/16	2 9/16	3 3/8
B	2 5/8 and up	3 3/4	1 7/8	1/4	5/8	1 5/8	7/8	5 5/8

Style "A" punch is recommended for all sizes of punches up to and including 2 9/16 inches, and style "B" for all sizes 2 5/8 inches and larger.

SCREW PUNCHES.

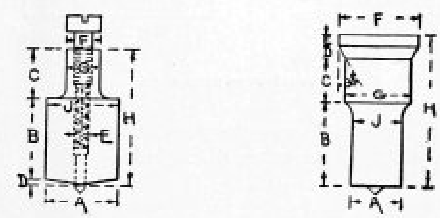
While the subject of standardizing screw punches may not interest all plate and structural workers, it should nevertheless receive the same general attention and consideration by



STYLE "B" PUNCHES, 2 5/8 INCHES AND UP.

this association as power punches have, and it may be said that one standard for this class of tool is not only desirable but essential, and the adoption of same should be given immediate consideration.

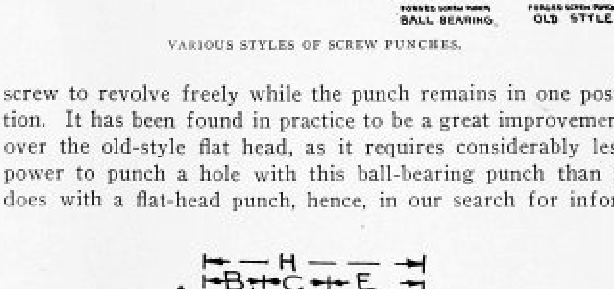
We are of the opinion that the old-style, flat-top punch should be discarded and the more up-to-date style brought into



STYLE "A" PUNCH. STYLE "B" PUNCH.

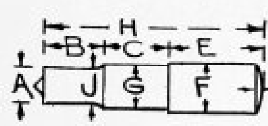
KEY TO TABLE FOR "A" AND "B" PUNCHES.

practice. This style, for convenience, we have called ball-bearing, as it gives a ball-bearing effect when riding on a hardened steel block of the same shape placed within the screw, which, when in operation, would act like two balls riding on each other. Such a construction will permit the



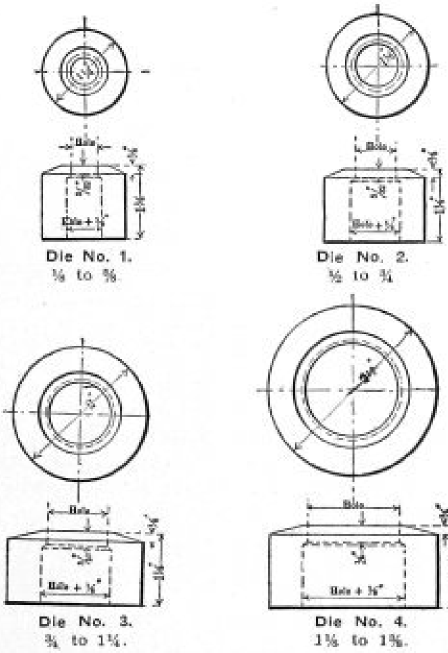
VARIOUS STYLES OF SCREW PUNCHES.

screw to revolve freely while the punch remains in one position. It has been found in practice to be a great improvement over the old-style flat head, as it requires considerably less power to punch a hole with this ball-bearing punch than it does with a flat-head punch, hence, in our search for infor-



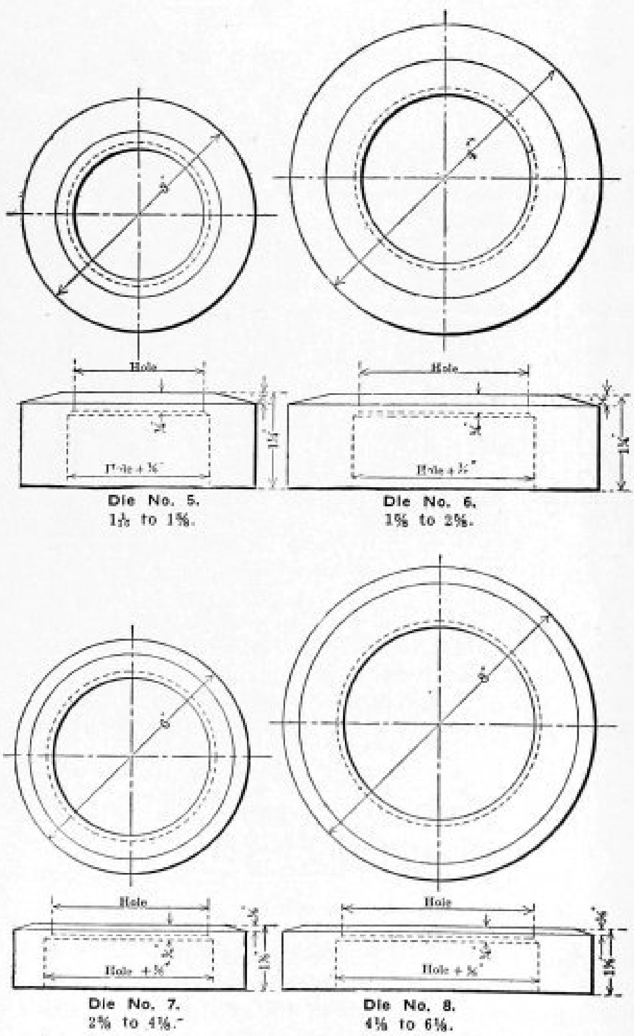
PROPOSED SCREW PUNCH.

mation pertaining to screw punches, we have been unable to ascertain any good reason why there should be two different styles of punches for this class of tool, and after due consideration your committee has come to the conclusion that a



PROPOSED STANDARD DIES.

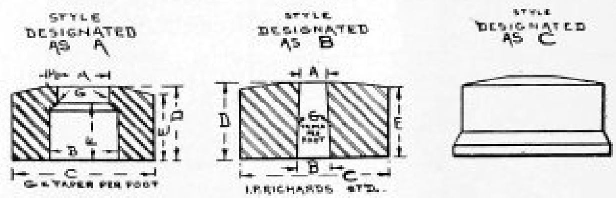
revision of this subject is necessary and that one of the styles must be adopted and the other discarded.



PROPOSED STANDARD DIES.

PROPOSED SCREW PUNCHES—INTERNATIONAL STANDARD.

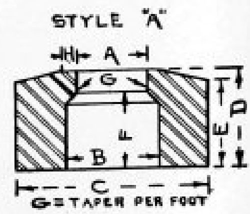
No.	A	B	C	D	E	F	G	H	J
1	1/8 to 11/16	23/32	21/32	1/16	1/16	47/64	43/64	2 1/2	3/8
2	1/4 to 13/16	7/8	7/8	1/16	1 7/16	55/64	53/64	3 1/4	3/4
3	1/2 to 15/16	1 1/4	7/8	3/32	1 13/32	1 3/32	15/16	3 3/8	3/4



POWER PUNCH DIES.

For the information of the members we show the dimensions of both C and D styles, as have been heretofore made by the various manufacturers.

We recommend that style D ball-bearing be adopted for all screw-punch purposes, dimensions of which are given in the accompanying table, and that the screws of all cast steel



PROPOSED SCREW PUNCH DIES (SEE TABLE).

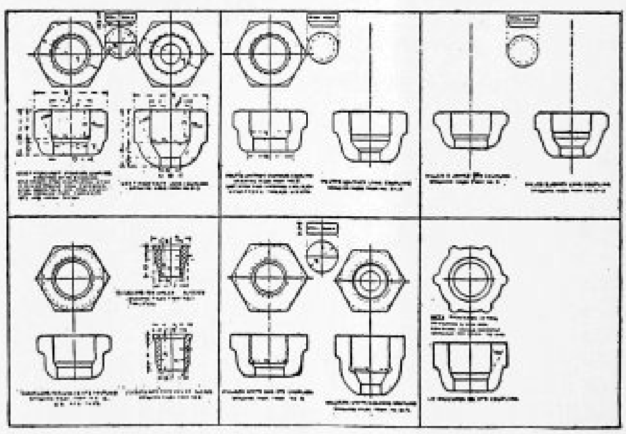
frames be changed to receive the style D punch; also that after this date the punch manufacturers abandon the manufacture of style C punch, and that all new screw punches of either cast or forged steel frames be equipped with style D punches.

Punch No. 1 will fit Nos. 0 and 00 punches.

Punch No. 2 will fit Nos. 1 and 2 punches.

Punch No. 3 will fit Nos 3 and 4 punches.

The above arrangement will greatly simplify the screw-punch problem, and give us a standard which, we believe,

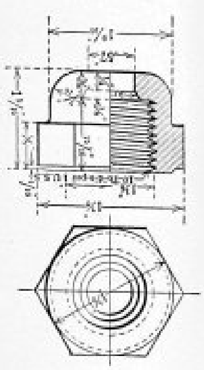


ALL STYLES OF COUPLINGS.

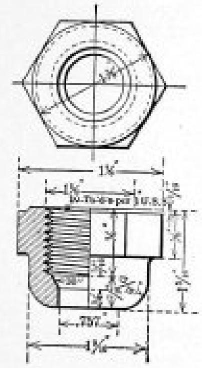
should commend itself to all those interested in the subject, and one which we recommend for adoption.

POWER-PUNCH DIES.

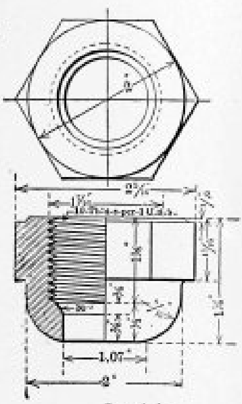
The matter of punch dies is a subject which has been given less consideration and attention by the manufacturers than either punches or couplings. These have been made in a haphazard way to almost any size or shape that a customer may specify. The die problem is one which requires imme-



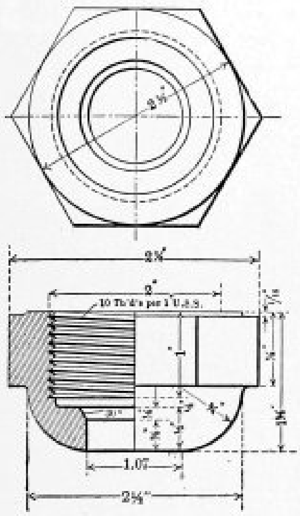
Coupling No. 1.
For Punch No. 1.



Coupling No. 2.
For Punch No. 2.



Special.
Coupling No. 3-S.
For No. 3 Punch.
No. 1 Punch with No. 1 Sleeve or
No. 2 Punch with No. 2 Sleeve.

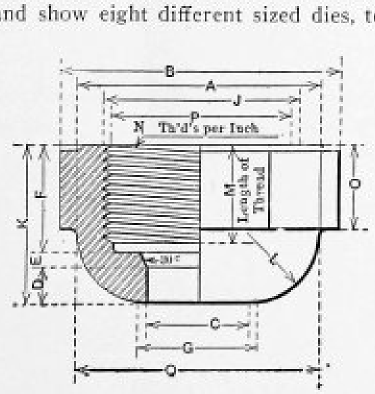


Coupling No. 3.
For No. 3 Punch.
No. 1 Punch with No. 1 Sleeve or
No. 2 Punch with No. 2 Sleeve

PROPOSED STANDARD COUPLINGS.

diate revolution, and war declared upon the hundred or more different sizes which should be cast aside and the new standard at once brought into vogue, if adopted. The committee recommends style "A" die for adoption.

We reproduce a cut from the approved tracing of a number of the standard dies, together with the recommendation of the committee, and show eight different sized dies, together with



KEY TO TABLE.

detailed dimensions of those which we recommend for adoption.

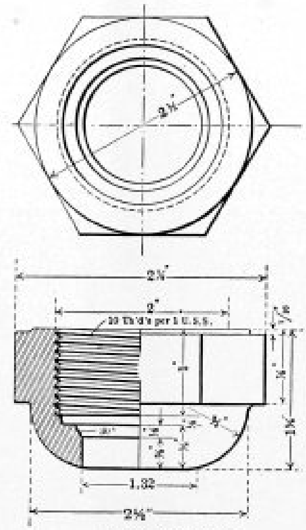
We show herewith three different styles of dies, and have designated them as styles A, B and C. Style A is that which is recommended by your committee for adoption. See opposite page for detail dimensions of power-punch dies.

SCREW-FRAME PUNCH DIES.

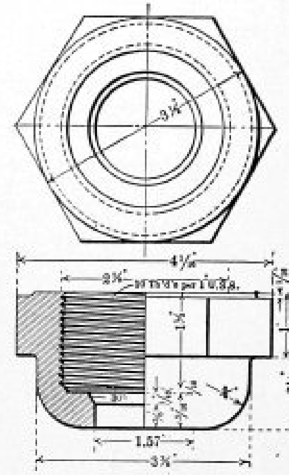
The subject of screw-punch dies has been given considerable attention, and has been reduced to three sizes of the following diameters: 1 5/16, 1⅝ and 1⅞ inches, as with these diameters we are able to accommodate all sizes of screw punches.

For detailed dimensions see accompanying table, which gives our recommendations in full.

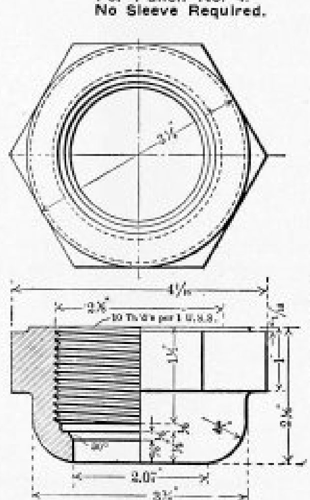
These dies have been given half numbers in order to avoid confusion, as will be seen from a glance at the table, and are as follows:



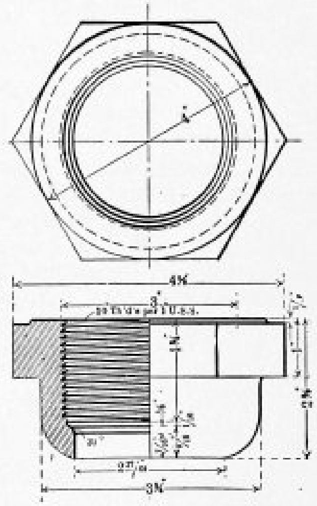
Coupling No. 4.
For Punch No. 4.
No Sleeve Required.



Coupling No. 5.
For Punch No. 5.



Coupling No. 6.
For Punch No. 6.
No Sleeve Required,



Coupling No. 7.
For Punch No. 7.
Sleeve No. 5 with Punch No. 5 or
Sleeve No. 6 with Punch No. 6.

PROPOSED STANDARD COUPLINGS.

PROPOSED SCREW PUNCH DIES—INTERNATIONAL STANDARD

No.	A	B	C	D	E	F	G	H
1½	⅛ to ¾	Diam. + ⅛	1 5/16	¾	⅝	19/32	¾	⅛
2½	½ to ⅞	Diam. + ⅛	1⅝	1	⅞	27/32	¾	⅛
3½	¾ to 1⅛	Diam. + ⅛	1⅞	1 1/16	15/16	⅞	¾	⅛

No. 1½ die intended for Nos. 0 and 00 cast steel frame punches.

No. 2½ die intended for Nos. 1 and 2 forged and Nos. 1 and 2 cast steel frame punches.

No. 3½ die intended for Nos. 3 and 4 forged and Nos. 3 and 4 cast steel frame punches.

PROPOSED INTERNATIONAL STANDARD POWER PUNCH COUPLINGS.

No.	A	B	C	D	E	F	G	J	K	L	M	N	O	P	Q
1	1 5/8	1 7/8	.57	1/4	1/8	15/16	3/4	1 1/8	1 5/16	7/16	15/16	10	7/8	1.095	1 9/16
2	1 5/8	1 7/8	.757	1/4	3/16	7/8	13/16	1 1/8	1 5/16	7/16	7/8	10	7/8	1.095	1 9/16
3S	2	2 5/16	1.07	3/8	1/8	1 1/8	1 5/64	1 7/16	1 5/8	9/16	1 1/4	10	13/16	1.307	2
3	2 1/2	2 7/8	1.07	3/8	1/8	1 1/8	1 5/64	2	1 5/8	3/4	1	10	7/8	1.87	2 1/2
4	2 1/2	2 7/8	1.32	3/8	1/8	1 1/8	1 11/32	2	1 5/8	3/4	1	10	7/8	1.87	2 1/2
5	3 1/2	4 5/16	1.57	3/8	5/16	1 9/16	2 1/8	2 5/8	2 1/8	3/4	1 1/2	10	1	2.495	2 5/8
6	3 1/2	4 5/16	2.07	3/8	1/8	1 1/8	2 1/8	2 5/8	2 1/8	3/4	1 1/2	10	1	2.495	3 5/8
7	4	4 5/8	2.57	7/16	1/8	1 13/16	2 5/8	3	2 3/8	3/4	1 3/4	10	1	2.87	3 3/4

1 5/16 inches diameter of die is now No. 1½; will fit Nos. 0 and 00 punches.

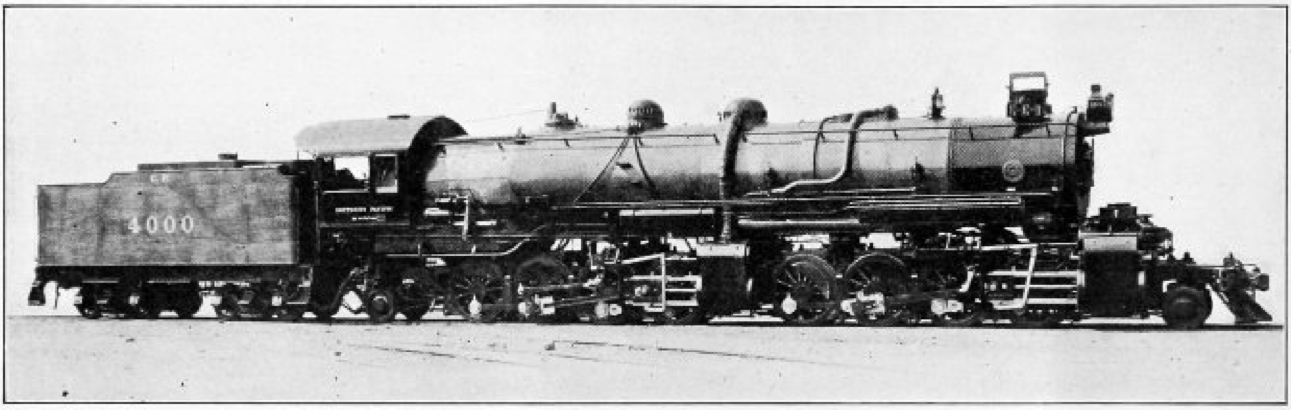
1⅝ inches diameter of die is now No. 2½; will fit Nos. 1 and 2 punches.

1⅞ inches diameter of die is now No. 3½; will fit Nos. 3 and 4 punches.

The numbers and dimensions as herein given are hereby recommended by the committee for adoption.

We have selected seven regular and one special coupling. Coupling 3S is a special coupling to be used only in cases where the body of the regular No. 3 coupling is too large, or when holes are to be punched close to the standing flange of angles, channels, beams or the flanges of heads, etc., and the only reason that this coupling is shown at all is in case it may at some time be necessary to resort to the use of such a coupling; hence we have given the dimensions for the benefit of those who may be obliged to use it. We show in this report several makes of couplings, all of which are laid out to the same scale. We also reproduce a cut of the tracing containing the dimensions recommended by the committee.

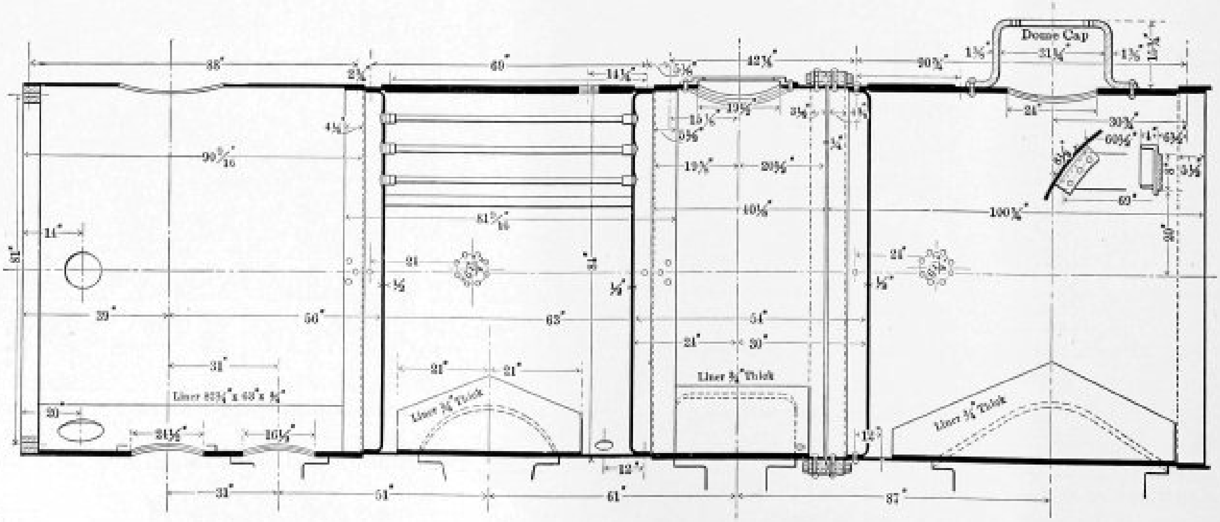
We also produce herewith detailed drawings and dimensions of the couplings, which we take pleasure in recommending to the association for adoption.



MALLET ARTICULATED LOCOMOTIVE, BUILT BY THE BALDWIN LOCOMOTIVE WORKS FOR THE SOUTHERN PACIFIC.

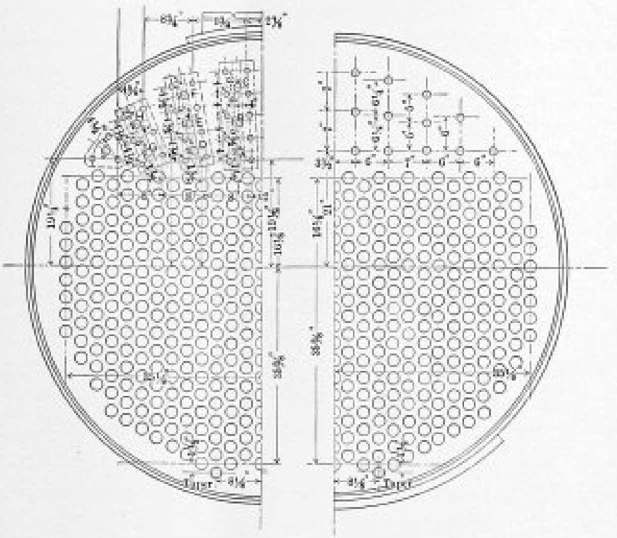
PUNCH COUPLINGS.

Your committee has chosen for your consideration a set of couplings which we believe are without fault. The depth of the wrench surface is one of the essential features of these couplings, as many other couplings have been incorrectly constructed. This corrects the evil of the too small wrench surface, which has been found objectionable in the past, especially when the stripper is in position.



SECTION OF BOILER, SHOWING FEED-WATER HEATER AND SMOKE-BOX.

While we do not feel justified at this time to recommend the quality of material to be used in punches and dies, the committee is of the unanimous opinion that couplings should be made of mild steel, drop forged and case hardened.

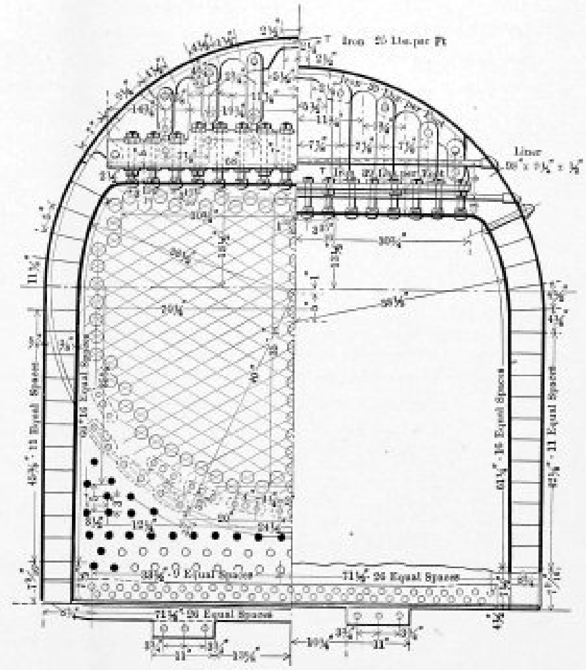


TRANSVERSE SECTIONS OF BOILER.

MALLET ARTICULATED COMPOUND LOCOMOTIVES FOR THE SOUTHERN PACIFIC COMPANY.

The Baldwin Locomotive Works have recently completed for the Southern Pacific Company two Mallet articulated compound locomotives, which are undoubtedly the heaviest engines thus far built for any railway. These locomotives have eight coupled wheels in each group, and in accordance with the previous practice of the builders are equipped with two-wheeled leading and trailing trucks. The constructive details embody various features of special interest. The calculated tractive force of this design is 94,640 pounds. The locomotives will be used on the Sacramento Division between Roseville and Truckee, where the maximum grade is 116 feet per mile, and the rating 1,212 tons of cars and lading.

The boiler is straight topped, 84 inches in diameter, and is equipped for oil burning. The fire tubes are 21 feet long; they terminate in a combustion chamber, 54 inches long, in front of which is a feed-water heater 63 inches in length. The tubes in the feed-water heater are set in alinement with the fire tubes, and are equal to them in number and diameter. Two non-lifting injectors are provided, and they discharge, right and

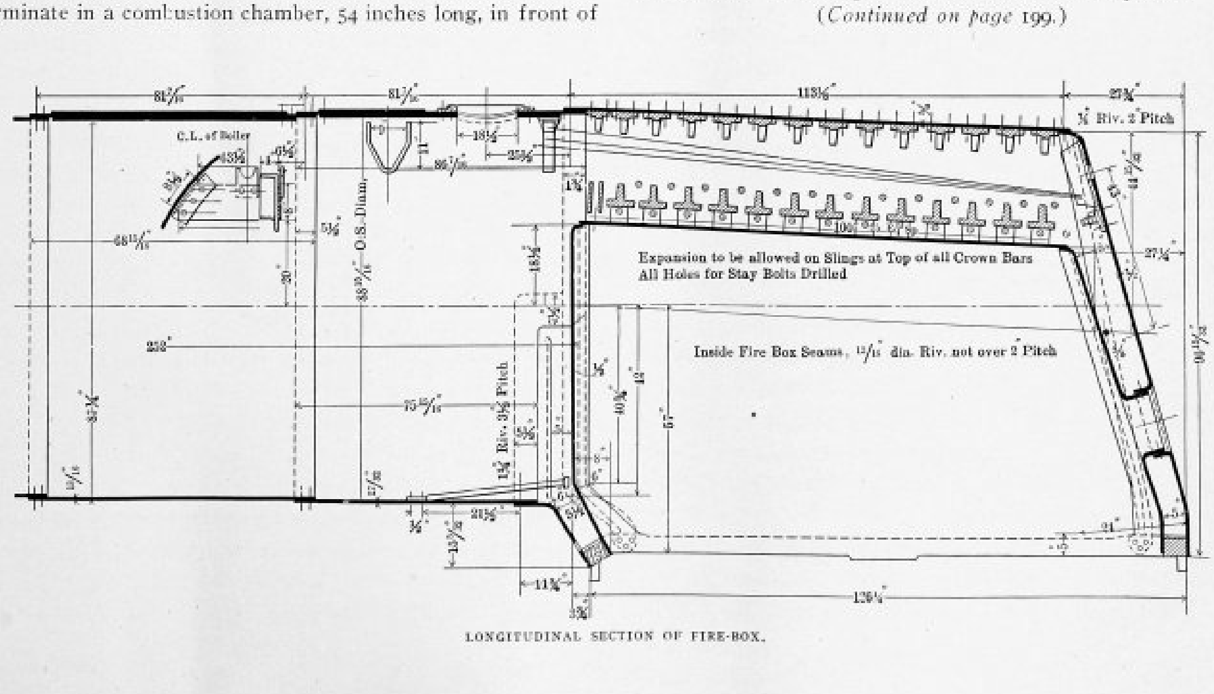


TRANSVERSE SECTIONS OF FIRE-BOX.

left, into the feed-water heater chamber, which is kept constantly filled with water. The feed passes out through the top of the chamber and is then delivered into the main barrel through two checks, placed right and left immediately back of the front tube sheet. A superheater, placed in the piping system between the high and low-pressure cylinders, is located in the smoke-box. The combustion chamber is provided with a manhole, so that the tube ends are readily accessible.

In order to facilitate repairs the boiler is provided with a separable joint, which is placed at the rear end of the combustion chamber. The joint is effected by riveting a ring to each boiler section and uniting the rings by 42 bolts, 1¼ inches in diameter. The rings are butted with a V-shaped fit.

(*Continued on page* 199.)



LONGITUDINAL SECTION OF FIRE-BOX.

The Boiler Maker

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Boiler Inspectors' Convention.

We are authorized by Mr. J. C. McCabe, city boiler inspector, Detroit, Mich., to announce a meeting of State and municipal boiler inspectors, to be held in Detroit, Mich., Aug. 10, 11 and 12. This meeting has been called for the purpose of forming a national organization of State and municipal boiler inspectors, which shall have for its main object the securing of more uniform boiler construction and inspection throughout the country. This is a movement which deserves the hearty support of every State or city boiler inspector in the country. The laws governing the construction and inspection of boilers, where any at all are in force, vary so widely that little can be said in favor of conditions as they are now. Some laws which are in force provide little or no protection as far as requirements for safe construction and operation are concerned. That these conditions should be changed is the opinion of every one who has given the matter any thought, but so far very little success has attended the efforts of any individuals or organizations which have attempted to better them.

The men on whom is placed the duty of enforcing these laws, that is, the State and city inspectors, are, perhaps, better qualified than any one else to recommend changes and ways and means of securing better conditions. For this reason the new organization of boiler inspectors will be gladly welcomed and given every encouragement in their work, both by boiler manufacturers and boiler users.

This meeting is to be held at a time when the Boiler Manufacturers' Asociation is holding its twenty-second annual convention in Detroit, and it is hoped that the older organization will be ready to give the new association the benefit of its experience in this same line of work; for much has already been done by the former association towards promoting the aims of the new organization.

Finally, in order that the new association may have a successful start, it is necessary that the attendance at the coming convention be large. We, therefore, urge every State and city boiler inspector in the country to make a special effort to be in Detroit on Aug. 10, 11 and 12, prepared to give his individual support to the new association.

Heat Transfer.

Not so very long ago engineers were more or less startled by the announcement made by the fuel testing department of the United States Geological Survey that steam boilers should be made to do from ten to twenty times the amount of work which they now do. Not long after that the results of a test were published, showing that the capacity of a well-known type of watertube boiler had been doubled by the use of two stokers, one under the front and one under the back of the boiler, with only a small loss in efficiency. More recently the results of some experiments on an English type of flue boiler have been presented before the Junior Institution of Engineers of England, where the capacity of the heating surface for the evaporation of water was greatly increased by increasing the velocity of the hot gases through the boiler. And now we are told by Dr. C. E. Lucke, of Columbia University, that there is very good promise that boilers of perhaps 100 times the present capacity might be developed with the same heating surface.

Dr. Lucke's statement was made in a paper recently presented before the Master Mechanics' Association, in which he described some experiments which have been made to determine, if possible, what law governs the rate of heat transfer between various liquids and gases. The coefficient which is universally used to measure the transfer of heat between substances of different temperature through a metallic surface is B. T. U. per square foot per hour per degree difference of temperature. Dr. Lucke shows that the value of this coefficient varies from 2 to nearly 1,000 under various circumstances. In any apparatus which involves the passage of heat from gases to a liquid, such as a steam boiler, the value is low, running from 2 to 4.

He concludes that the only variable which seems to affect the coefficient in the latter case is the gas temperature, which may or may not be associated with gas velocity. His tests show that it is not a problem of getting the metal to give up heat to the water, but of getting the gas to give up heat to the metal. For, no matter what is done on the water side, it will not affect the rate of heat transfer. His conclusions point to the fact that attention must be paid to the gas side of the heating surface, the important point being the removal of the cooled-off gas particles which cling to the heating surface, forming a film, which greatly retards the transfer of heat, and the bringing into contact with the dry side of the heating surface other heated particles of gas.

Mallet Articulated Compound Locomotives for the Southern Pacific Company.

(*Continued from page 197.*)

The waist-bearer under the combustion chamber is bolted into place, while the front waist-bearer and the high-pressure cylinder saddle are riveted to the shell. The longitudinal seams in the barrel are placed on the top center line and have "diamond" welt strips inside. Flexible stay-bolts are liberally used in the sides, back and throat of the fire-box, while the crown sheet is stayed with tee-irons hung on expansion links, in accordance with Associated Lines practice.

The dome, which is of cast steel, is placed immediately above the high-pressure cylinders, and the arrangement of the throttle and live steam pipes is similar to that used on heavy articulated locomotives previously built at these works. The exhaust from the high-pressure cylinders passes into two pipes which lead to the superheater. These pipes are of steel, and each is fitted, at the back end, with a slip joint made tight with a packed gland. The steam enters the superheater at the front end of the device and passes successively through six groups of tubes. It then enters a T-connection, from which it is conveyed to the low-pressure cylinders through a single pipe having a ball joint at each end and a slip joint in the middle. Each low-pressure cylinder is cast separately and is bolted to a large steel box casting, which is suitably cored out to convey the steam from the receiver pipe to a pair of short elbow pipes, making final connection with the low-pressure steam chests. The distribution is here controlled by 15-inch piston valves which are duplicates of those used on the high-pressure cylinders. The final exhaust passes out through the front of each casting into a T-connection, which communicates with a flexible pipe leading to the smoke-box. The slip joint in this pipe is made tight by means of snap rings and leakage grooves. At the smoke-box end the ball joint is fitted with a coiled spring, which holds the pipe against its seat. The valves for both the high and low-pressure engines are set with a travel of 5½ inches and a lead of 5/16 inch. The steam lap is 1 inch, and the exhaust clearance 1/16 inch. The high-pressure cylinders are oiled from a lubricator placed in the cab, while a force-feed pump, driven from the forward valve motion, is provided for the low-pressure cylinders. This arrangement obviates the use of flexible oil-pipe connections.

Reversing is effected by the Ragonnet power gear, which is operated by compressed air and is self-locking. The gear is directly connected to the high-pressure reverse shaft. The reach-rod connection to the low-pressure reverse shaft is placed on the center line of the engine, and is fitted with a universal joint located immediately above the articulated frame connection. The joint is guided between the inner walls of the high-pressure cylinder saddle. In this way the reversing connections are simplified, and when the engine is on a curve the angular position of the reach rod has practically no effect on the forward valve motion. This arrangement has been made the subject of a patent.

One of the locomotives is equipped with vanadium steel frames, and the other with frames of carbon steel. The connection between the frames is single and is effected by a cast steel radius-bar, which also constitutes a most substantial tie for the rear end of the front frames. The fulcrum pin is 7 inches in diameter; it is inserted from below, and held in place by a plate supported on a cast steel crosstie, which spans the bottom rails of the rear frames between the high-pressure cylinders. The weights on the two groups of wheels are equalized by contact between the front and rear frames, no equalizing bolts being used in this design.

The front frames are stopped immediately ahead of the leading driving pedestals, where they are securely bolted to a large steel box casting, previously mentioned, which supports the low-pressure cylinders. The cylinders are keyed at the front only. The bumper beam is of cast steel, 10 feet long, while the maximum width over the low-pressure cylinders is approximately 11 feet.

The boiler is supported on the front frames by two bearings, both of which have their sliding surfaces normally in contact. The front bearing carries the centering springs, and the wear is taken in each case by a cast iron shoe 2 inches thick. Both bearings are fitted with clamps to keep the frames from falling away when the boiler is lifted.

This locomotive naturally embodies in its design many smaller details of interest. The cylinder and steam chest heads are of cast steel, the low-pressure heads being dished and strongly ribbed. The low-pressure pistons are also dished; they have cast steel bodies, and the snap rings are carried by a cast iron ring which is bolted to the body and widened on the bottom. The links for the low-pressure valve gear are placed outside the second pair of driving wheels and are supported by cast steel bearers, which span the distance between the guide yoke and the front waist-bearer. The low-pressure valve stems are connected to long cross-heads, which slide in brackets bolted to the top guide bars. The locomotive is readily separable, as the joint in the boiler is but a short distance ahead of the articulated frame connection, and all pipes which pass the joint are provided with unions. The separable feature was tested by the builders and proved entirely feasible. Sand is delivered to the rear group of driving wheels from a box placed on top of the boiler, and to the front group from two boxes placed right and left ahead of the leading drivers.

The tender is designed in accordance with Associated Lines standards and is fitted with a 9,000-gallon water-bottom tank. The capacity for oil is 2,850 gallons. The trucks under both the locomotive and tender are equipped with "Standard" solid-forged and rolled-steel wheels.

The detail parts of this locomotive have, where possible, been designed in accordance with existing standards of the Associated Lines. The engine is practically equivalent, in weight and capacity to two large Consolidation type locomotives, and in spite of its great size presents a pleasing and symmetrical appearance.

The principal dimensions of the locomotives are as follows:

Gage	4′ 8½″
Cylinders	26″ & 40″ x 30″
Valves	balanced piston.

Boiler.

Type	straight.
Material	steel.
Diameter	84″
Thickness of sheets	13/16″ & 27/32″
Working pressure	200 lbs.
Fuel	oil.
Staying	⊥ crown bars.

Fire-Box.

Material	steel.
Length	126″
Width	78¼″
Depth, front	75½″
Depth, back	70½″
Thickness of sheets, sides	⅜″
" " " back	⅜″
" " " crown	⅜″
" " " tube	½″

Water Space.

Front	5″
Sides	5″
Back	5″

Tubes.

Material	steel.
Thickness	0.125″
Diameter	2¼″
Number of firetubes	401
Length of firetubes	21′ 0″
No. feed-water heater tubes	401
Length " " "	5′ 3″

Heating Surface.

Fire-box	232 sq. ft.
Firetubes	4,941 " "
Feed-water heater	1,220 " "
Total	6,393 " "
Grate area	68.4 " "

Driving Wheels.

Diameter, outside	57″
Diameter, center	50″
Journals, main	11″ x 12″
Journals, others	10″ x 12″

Engine Truck Wheels.

Diameter, front	30½″
Journals	6″ x 10″
Diameter, back	30½″
Journals	6″ x 10″

Wheel Base.

Driving	39′ 4″
Rigid	15′ 0″
Total engine	56′ 7″
Total engine and tender	83′ 6″

Weight.

On driving wheels	394,150 lbs.
On truck, front	14,500 "
On truck, back	17,250 "
Total engine	425,900 "
Total engine and tender, about	596,000 "

Tender.

Wheels, number	8
Wheels, diameter	33½″
Journals	6″ x 11″
Tank capacity, water	9,000 gals.
Tank capacity, oil	2,850 "
Service	freight

The engines are equipped with Baldwin smoke-box superheaters, having a superheating surface of 655 square feet.

TECHNICAL PUBLICATIONS.

The Economy Factor in Steam Power Plants. By George W. Hawkins. Size, 6 by 9 inches. Pages, 133. Figures, 49. New York, 1908: Hill Publishing Company. Price, $2.

The problems of power plant efficiency and economy are among the most important which must be met by the engineering profession. The possibility of a future scarcity of fuel and the certainty of increasing fuel costs lend additional weight to the subject. Moreover, the subject is one on which too often the designer is placed upon his own resources, so that he can obtain little information outside of what he has collected during his own experience as an engineer. In fact, there has been a tendency for individual members of the profession to jealously guard such information as part of their most valuable assets. Perhaps this feeling accounts for the fact that up to the present time little has been published treating comprehensively of this subject. The data used in compiling the work under review have been carefully selected from the results of actual experiments, all unauthentic reports and manufacturers' claims being absolutely discarded. One can be reasonably certain, therefore, that he has before him an authentic collection of data upon the economic performance of various pieces of apparatus which are used in a steam power plant.

The book is divided into four parts, the first taking up individual apparatus, such as boilers, engines, electrical generators, condensing apparatus, feed pumps, oil pumps, oil burners, feed-water heaters and fuel economizers. Part II. discusses the factor of evaporation, showing its effect upon complete plant economy and also the influence of the various auxiliaries upon it. In Parts III. and IV. the complete plant economy is considered, the full rated load being taken up in Part III. and the variable load in Part IV. Although it was the original intention to make the work apply only to oil-burning plants, yet the necessary conversion charts have been added, so that the results may be readily converted from oil to coal or wood, as desired. The part of the book relating to boiler efficiencies refers primarily to oil-burning practice.

The Engineering Index Annual for 1908. Size, 6½ by 9 inches. Pages, 437. New York and London, 1909: *The Engineering Magazine.* Price, $2.

From the years 1884 to 1891, *The Engineering Index* was published by the Association of Engineering Societies, under the direction of Professor J. B. Johnson. From 1892 to 1895, the *Index* was edited by the Association of Engineering Societies, under the direction of Professor Johnson and published by *The Engineering Magazine.* Since 1896 the book has been both edited and published by *The Engineering Magazine.* The present work comprises the seventh volume, and includes classified lists of the most important articles published in the technical press during the year. Each article is briefly described, and information is given regarding the issue of the publication in which it appeared. In the 1908 volume, 8,248 articles are indexed, exclusive of cross-references, as compared with 7,848 in the 1907 volume. This gain in range has been obtained without material increase in the size of the book, as more careful attention has been given to conciseness in writing the descriptive legends.

Logarithms for Beginners. By Charles M. Pickworth. Second Edition. Size, 5 by 7¼ inches. Pages, 47. New York, 1908: D. Van Nostrand & Company, 23 Murray street. Price, 50 cents net.

In this edition the subject-matter has been slightly revised and a few numerical errors corrected. The book should be a valuable aid to beginners, who find difficulty in grasping the root principle of calculating by means of logarithms. The explanation of logarithms is far more detailed and practical than is usually found in text-books.

PERSONAL.

WILLIAM HORSLEY, who severed his connection with the Bigelow Company, New Haven, Conn., June 1, to take charge of the Eastern warehouse and plant of the Patterson-Allen Engineering Company, Jersey City, N. J., where the Horsley pressed steel boiler nozzles are to be manufactured, was given a dinner at the Hotel Shoreham, Morris Cove, New Haven, Conn., May 29, 1909, by his associates from the Bigelow Company. The guests included many of the officers of the Scully Steel & Iron Company, Chicago, Ill., and the Patterson-Allen Engineering Company, Jersey City, N. J., as well as officers and employees of the Bigelow Company and representatives of other prominent manufacturing concerns in New Haven and of THE BOILER MAKER, of New York.

WILLIAM HORSLEY.

E. L. HUDSON, formerly of the Hendrick Manufacturing Company, of Carbondale, Pa., has purchased a half interest in the Kaw Boiler Works, of Kansas City, Kan. This concern does a general line of sheet-steel and structural work.

Obituary.

Francis X. Pund, vice-president of the D. T. Williams Valve Company, Cincinnati, Ohio, passed away at his home, after a brief illness, Saturday morning, May 8. Mr. Pund was born in Cincinnati and at an early age secured a position with Post & Company, and remained with them until the discontinuance of the business. He accepted a position with Post & Company, and after faithfully serving this firm for eight years, he and one of his fellow employees, Mr. Geo. Puchta, bought out Post & Company, and continued business under the name of Puchta, Pund & Company, and later as the Queen City Supply Company, which became one of the best known and most successful mill and factory supply houses in the country.

In 1904, after a long and successful career, he entered the manufacturing business, and with David T. Williams, formerly general manager of the Lunkenheimer Company, founded the well-known firm of the D. T. Williams Valve Company, where he eclipsed his former successes and with his associates helped to build one of the largest valve concerns in the country. He was 58 years old.

COMMUNICATIONS.

Stresses in a Cylindrical Shell.

Editor The Boiler Maker:

The amount of energy which is internally stored in a cylindrical shell under pressure is a subject of much importance, and if thoroughly understood a great many old and worn-out boilers which are now in service would undoubtedly be consigned to the scrap pile. It is not unusual to find in some instances boilers of ancient design—twenty-five to thirty-five

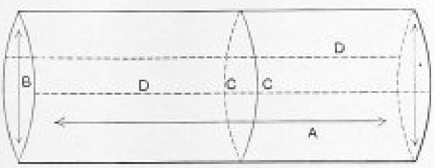


Fig. 1.

years old—being operated under a factor of safety as low as 3.5. Statistics show that out of all the boiler explosions which have occurred up to the present time the ordinary externally-fired tubular boiler has caused the greatest havoc.

When comparing the volume of some of the larger sizes of this type with the smaller cylindrical drums of the watertube boiler, the energy within is quadrupled when the diameter is doubled. Assuming, for comparison, a cylindrical shell 30 inches diameter by 16 feet in length, and subjected to an internal pressure of 100 pounds per square inch. The total number of cubic inches in the shell is $(30)^2 \times .7854 \times 12 \times 16 = 135,717.12$. In comparing this with one 60 inches diameter by 16 feet long, the total number of cubic inches is $(60)^2 \times .7854 \times 12 \times 16 = 542,868.48$, which is four times the capacity of the 30-inch shell. Therefore the total energy in the larger shell at 100 pounds pressure which depends directly

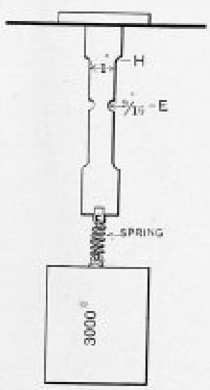


Fig. 2.

upon the quantity of water and steam in the shell is four times the energy in the small drum.

Thus, when this enormous amount of energy is suddenly liberated, disastrous results are sure to follow, especially in large establishments or in thickly populated districts. In recent years, however, men of marked ability have given this subject careful study. Experimental tests of wide description have been made from which rules have been deduced which have gradually elevated the standard of construction, economical and safe operation of the steam boiler, and, as a result, the old-fashioned methods have to a great extent been relegated to the past.

In computing the action of an internal pressure on a cylindrical shell, there are two forces tending to rupture it. One force acting in a longitudinal direction, as at *A*, Fig. 1, has a tendency to tear the shell in a transverse plane or circular direction, as at *C*, while the other force, acting in the opposite direction, as indicated at *B*, tends to rupture the boiler in a longitudinal plane, or from head to head, as at *D*.

To operate along safe lines, the resistance to these two forces of stored-up energy must be much greater than the stress due to the internal pressure. Suppose the 60-inch boiler, previously mentioned, is constructed of 3/8-inch material, having a tensile strength of 60,000 pounds per square inch. The internal pressure acting in a direction at right angles to a longitudinal plane on each side of the boiler is $100 \times 60 \times 192 = 1,152,000$ pounds, and the resistance to this is $.375 \times 2 \times 192 \times 60,000 = 8,640,000$ pounds, or 7.5 times greater than the stress due to the internal pressure. The pressure acting in the opposite direction is $60^2 \times .7854 \times 100 = 292,744$ pounds, and this is resisted by $(60.75^2 \times .7854 - 60^2 \times .7854)$ $60,000 = 4,267,200$ pounds, or about fifteen times greater than the stress due to the internal pressure. Thus it is seen that there is twice as much resistance to transverse rupture as there is to rupture in a longitudinal plane. For this reason the girth or transverse seams are designed much weaker than the longitudinal seams, and if the latter are designed to withstand the desired pressure the former will possess ample resistance.

In designing the longitudinal seams of the lap-joint type, strict attention should be given to equalizing the shearing strength of the rivets and the tensile strength of the net section of the plate, which also refers to the butt-joint type with single-covering plate. It should be the aim of the builder to get as high an efficiency as possible, but in order to do this care should be exercised to avoid spacing the rivet holes too far apart, as in this case it may be difficult to do a good job of calking. In the usual lap-joint design, a loss in efficiency of from 25 to 44 percent is taken from the solid plate, depending on the number of rows and spacing of rivet holes. In the 60-inch boiler mentioned above, we will assume for convenience that the loss is 43 percent. The stress on each square inch of the shell is $30 \times 100 = 3,000$ pounds. The least resistance to this—which is along the longitudinal seam—is $.375 \times 60,000 \times .57 = 12,825$ pounds, or about 4.3 times greater than the internal pressure if the load is steady. A better understanding of this may be had by referring to Fig. 2, which represents a strip of plate 1 inch wide at *H* and 9/16 inch wide at *E*. The width of plate at *H* refers to 1 square inch of plate in the boiler. *E* denotes the loss in efficiency per square inch by the punching out of the rivet holes in the longitudinal seam, and the 3,000 pounds weight represents the stress on each square inch of the shell. The weight is attached to the lower end by means of a spring, and when stationary the resistance at *E* is about 4.3 greater or similar to that in the boiler. Suppose, now, that if sufficient force is applied in any convenient manner the weight will move up and down; compare the number of times the weight moves up and down with the speed of an engine—the power of which is derived from the boiler—that is, each movement of the weight to be considered the same as one stroke of the piston.

When the steam port closes and cuts off the supply of steam from the boiler, the volume is decreased and the pressure in the boiler is momentarily increased in proportion, and at the same time the resistance, or factor of safety, decreases. The weight in descending has the same effect at *E*. When the steam port opens the volume increases, the pressure in the boiler decreases in proportion and the resistance is greater. In like manner when the weight ascends the stress at E is decreased and the resistance is greater.

It is therefore evident that the action of the weight and piston has the same effect, that of causing a constant expansion and contraction, and when severe has a tendency to gradually stretch the plate, or in the event that the load is increased sufficient to decrease the resistance to about twice the amount of the load, the plate will yield to such an extent that it will not return to its original thickness. This is the point where the applied stress causes the plate to reach the elastic limit, which is generally considered to be about 50 percent of the ultimate tensile strength.

Many boiler explosions have occurred through carelessness on the part of some inexperienced person, who, without resorting to any calculations whatever, subjects the boiler to a severe hydrostatic test to such an extent that the plates are stretched to a permanent elongation. The fatal mistake is not discerned, the boiler is fired up, and in the course of time the weakened plates gradually lose their resistance, until, finally, rupture occurs.

It is not always the old, worn-out boilers, however, that create such havoc. It occasionally occurs that a boiler supposed to be well designed and carefully managed by experienced hands suddenly gives way. One of the most dangerous defects responsible for this is the hidden crack in the longitudinal seam, generally concealed in such a manner that detection is impossible. This is generally attributed to faulty construction of the plates or poor workmanship in joining them together. The violent use of the drift pin in rivet holes that do not match is a source of great danger, especially when applying a new sheet to an old boiler by inexperienced hands. The number of boiler explosions are being gradually diminished, as a result of a better understanding of the improved methods of construction and management as advocated by leading authorities. The periodical inspection by competent men is considered one of the most important features in maintaining a high standard of efficiency and safety for the operation of the steam boiler. J. H. SPARROW.

ENGINEERING SPECIALTIES.

Two New Hydraulic Jacks.

Any one who has much heavy lifting to do appreciates that there are pleasanter tasks than carrying around a jack from one place to another, especially when it weighs more than 100 pounds. It means rather a heavy load if carried by hand, and if the jack is loaded and reloaded onto a truck with each using, this involves considerable work, too. The new Watson-Stillman shop jack, which we show in the first illustration, renders unnecessary much of this labor. This jack, made in eleven sizes, of from 20 to 50 tons capacity, and lifts of 12 and 18 inches, fills all the ordinary requirements of lifting heavy machinery for general shop work. The wheels on the base and the handle on the cylinder facilitate moving the jack quickly from one place to another without the exertion of a great deal of energy. The wheels touch the floor only when the jack is tilted, so they are never in the way during the lifting operation. If it is desired to use the jack at an angle it can be tilted in the opposite direction to the wheels, and when it is laid flat upon the side, the ram will push out its entire lifting length. The head is enlarged sufficiently so that the jack will not stop working for lack of filling, even if there has been slight leakage. An independent steel claw (not shown in the illustration) can be used when desired for lifting from near the ground. This is more convenient than a permanently-attached claw, as the independent part is easily applied when a low lift is required, and its removal at other times allows the jack to be made of considerably lighter weight. The weight, however, is comparatively small, because the whole jack is made from steel, and the parts under greatest strain, such as the ram and cylinder, are machined

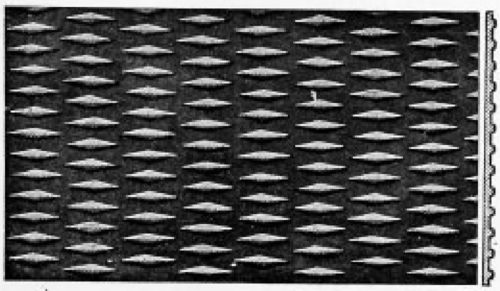
from a solid bar of higher carbon steel than usually found in hydraulic or other jacks.

It is sometimes inconvenient to work the lever of a jack of the internal-pump type, because of the lack of room or insufficient footing. There are other places where only a short space is available to place the jack—another condition which cannot be met successfully with the ordinary inside pump

jack. This is especially true in bridge, ship and drydock work, etc. Even in more common work it is sometimes to the operator's advantage, in the way of getting a better footing, more power or safety, to be at a considerable distance away from the jack. To meet these conditions the Watson-Stillman Company put upon the market the independent pump hydraulic jack shown in the second illustration, and which they furnish in fifty-three sizes of from 2 to 1,200 tons capacity. The various sizes of the jack proper have maximum ram movements of from 4 to 8 inches. The pump is connected to the jack by means of flexible copper tubing, which may be of any length suitable to the work in question. The jack may be operated up to a pressure of 450 pounds per square inch on the ram by means of the hand lever shown on the pump, and further worked to full capacity by means of the extension lever. The gage may read in pounds per square inch, or in tons-load upon the jack, or both. This is not furnished when the jack is to be used for ordinary lifting, but is necessary in testing. When equipped with the gage the jack may be used between two fixed platens for making compression tests, testing the tightness of forced fits, etc.

Wrought Steel Floor Plate.

The usefulness of wrought steel floor plates is rapidly increasing and whereas they were formerly largely used for floors, platforms, trough coverings in boiler shops, engine rooms, factories, basements, etc., they are now coming into general use for running boards on locomotives and brake-



men's platforms on steel gondola cars. Diamond pattern floor plates for this purpose are being manufactured by the Scully Steel & Iron Company, Chicago, Ill., the plates being rolled from open-hearth steel from 1/8 to 1/2 inch thick. It is claimed that these plates weigh only one-third as much as cast iron of equal strength.

SELECTED BOILER PATENTS.

Compiled by

DELBERT H. DECKER, ESQ., Patent Attorney,

LOAN AND TRUST BUILDING,

Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

919,528. STEAM BOILER. WALTER AUTHER BERRY, OF CHATTANOOGA, TENN., ASSIGNOR OF ONE-HALF TO RAYMOND W. FRAWLEY, OF CHATTANOOGA, TENN.

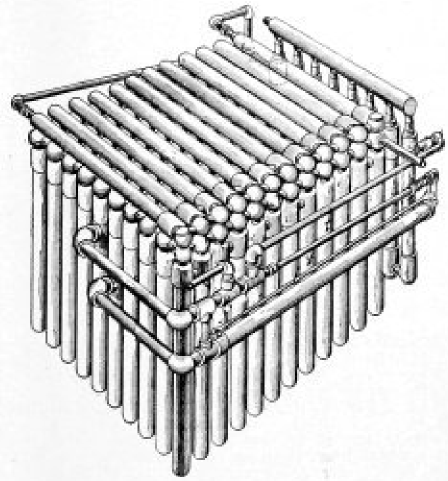
Claim 1.—In a boiler, the combination of an outer main shell, an inner auxiliary shell forming with the latter a water space around the outer portion of the boiler and having a water-containing baffle plate continued therefrom and provided with angular legs, a furnace, a hollow bridge wall at the rear of the furnace communicating with the said water space, and a series of watertubes connected to the front and rear portions of the water space and to the angular legs and bridge wall. Three claims.

920,153. BOILER. MICHAEL KELLY, OF BUFFALO, N. Y.

Claim 2.—A boiler having an upright water leg, which is provided on its inner side with a laterally-projecting hollow extension, an upright partition arranged within said extension and terminating at its upper and lower ends short of the top and bottom of said extension, and an upright flue arranged in said extension between the salient part thereof and said partition and opening at its upper and lower ends through the top and bottom of the extension. Three claims.

917,621. STEAM GENERATOR. JOHN N. LEACH, OF MELROSE, MASS., ASSIGNOR, BY MESNE ASSIGNMENTS, TO JUDSON L. THOMSON MANUFACTURING COMPANY, OF WALTHAM, MASS., A CORPORATION OF MAINE.

Claim 1.—In a steam generator, the combination of a plurality of separable sections or units, each comprising a plurality of pendent tubes closed at the bottom, means in each of said tubes whereby a direct and a return channel is formed therein, means whereby said return channels are placed in direct communication with said direct



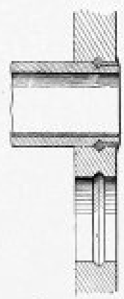
channels in succeeding adjoining tubes, and means whereby the opposite ends of each section or unit are placed in communication with succeeding and preceding adjoining sections or units, respectively, all of said parts being so constructed and arranged as to form therein a single continuous channel extending through each and all of said tubes. Five claims.

920,369. SMOKE-FLUE DAMPER FOR FEEDING AIR TO COMBUSTION CHAMBERS. GLADYS ISABELLA MUNSON, OF INDIANAPOLIS, IND.

Claim 1.—In combination with a smoke flue, a damper mounted therein and having tubular journals provided with wall openings and an air receiving and heating chamber communicating with said journals and provided with exit openings, air receiving and heating chambers upon the outer walls of the smoke flue supplementing and inclosing the damper journals, registering means within the tubular journals for controlling their wall openings to regulate the feed of the air from the chambers into the damper chamber, and means for adjusting the damper. Eleven claims.

920,743. BOILER-FLUE CONNECTION. DANIEL B. HINES, OF NORFOLK, NEB.

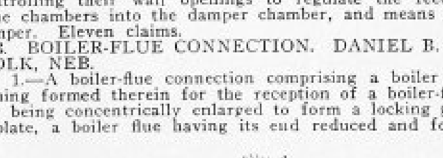
Claim 1.—A boiler-flue connection comprising a boiler plate having an opening formed therein for the reception of a boiler-flue end, said opening being concentrically enlarged to form a locking groove in the boiler plate, a boiler flue having its end reduced and formed with a



peripheral groove adapted to register with the locking groove of the boiler plate, and means for welding or brazing the boiler-flue end to the boiler plate disposed in the grooves of said flue and plate and between the reduced end of the flue and the adjacent portion of the plate. Three claims.

920,479. BOILER. HANS O. KEFERSTEIN, OF NEW ORLEANS, LA.

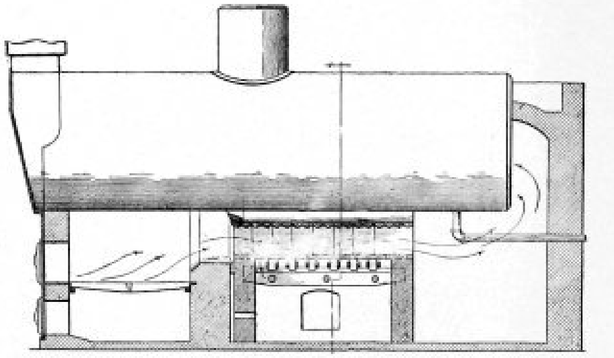
Claim 1.—The combination, with a header provided with a steam chamber and a water chamber arranged side by side, and a second header having a single chamber for both steam and water; of a fire tube having its end portions projecting through the said headers, a



water and steam tube encircling the said fire tube and provided with an opening connecting it with the said single chamber, said water and steam tube having its upper part connected with the said steam chamber and its lower part connected with the said water chamber, and means for closing the end of the said water and steam tube which projects through the said second header. Two claims.

921,087. SMOKE-CONSUMING FURNACE. GEORGE CRYSLER, OF CHICAGO, ILL.

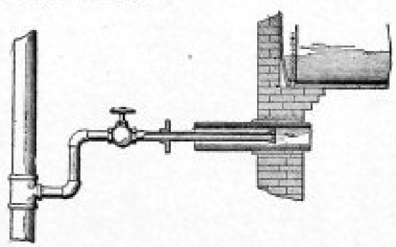
Claim 2.—In a furnace the combination with a grate and bridge wall, of a structure in rear of said bridge wall independent thereof, comprising two transverse walls, separated longitudinal bearing bars supported therein, a central longitudinal beam, independent transverse ribs extending from opposite sides of said central beam, and bearing upon the side bearing bars, a fire-proof lining carried by said ribs, and a transversely concave flue structure supported upon said lining, and



providing longitudinal flues therethrough, having bottom openings to the space between the cross-walls. Four claims.

921,139. GAS BURNER. JERRY J. MOORE, OF MOUND VALLEY, KAN.

Claim 1.—In a gas burner for boiler furnaces or the like, the combination with a gas inlet pipe having a reduced outlet at its inner or delivery end, of a mixing tube or cylinder having a cylindrical chamber throughout its length and open at both ends, said tube or cylinder in-



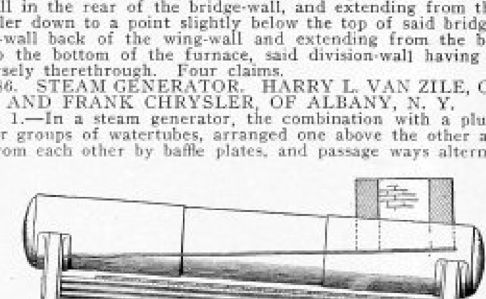
closing said inlet pipe, and a sleeve or bushing fixed in the furnace wall and in which said cylinder has a sliding fit to permit endwise longitudinal movement thereof for the purpose of varying the relative positions of the inner or delivery end of said gas inlet pipe and the inner end of said mixing tube or cylinder., Two claims.

921,169. FURNACE. CHARLES SCHWEIZER, OF BOSTON, MASS.

Claim 1.—In a furnace, a boiler, a fire-box at one end thereof, a grate in the fire-box, a series of equidistantly-spaced gas-deflecting arches in said fire-box disposed above the grate and removed from the boiler, a gas-deflecting and guiding bridge-wall at one end of the fire-box, said bridge-wall terminating short of the boiler, and being removed from the arches but in the path of the flame and gases produced at the grate, a wing-wall in the rear of the bridge-wall, and extending from the aforesaid boiler down to a point slightly below the top of said bridge-wall, a division-wall back of the wing-wall and extending from the boiler entirely to the bottom of the furnace, said division-wall having passages transversely therethrough. Four claims.

921,486. STEAM GENERATOR. HARRY L. VAN ZILE, OF NEW YORK, AND FRANK CHRYSLER, OF ALBANY, N. Y.

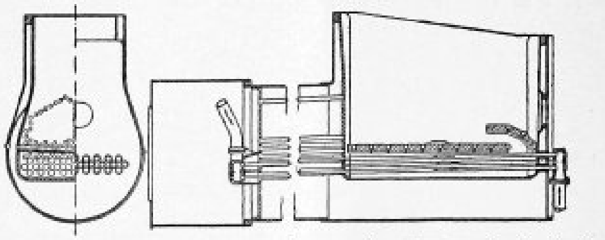
Claim 1.—In a steam generator, the combination with a plurality of banks or groups of watertubes, arranged one above the other and separated from each other by baffle plates, and passage ways alternately ar-



ranged in said baffle plates, of a furnace chamber divided into two separate combustion chambers, and a roof or ceiling, for each combustion chamber, provided at its outer or forward end with a gas passage, whereby one of said combustion chambers may be run independently of the other. Five claims.

922,200. SUPERHEATER FOR BOILERS OF THE LOCOMOTIVE TYPE. WILHELM SCHMIDT, OF WILHELMSHOHE, NEAR CASSEL, GERMANY.

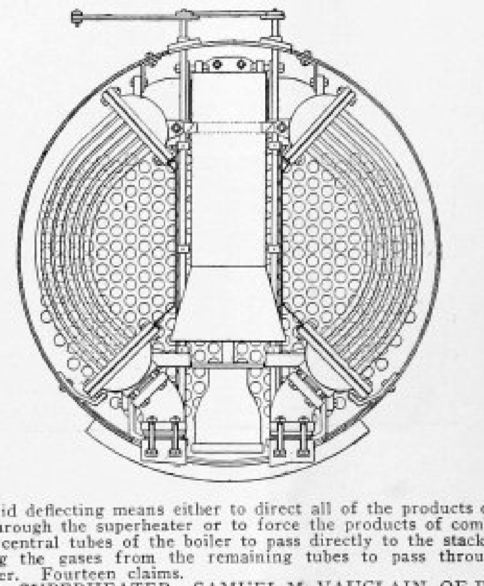
Claim 1.—In a steam superheater, for use with a locomotive boiler provided with three rows of enlarged smoke tubes in the upper part thereof, the combination of superheater tubes extending from the smoke-box of the boiler through the lowest row of said enlarged smoke tubes and fire-box and through the back wall of the boiler, a saturated steam header at said back wall connected to said superheater tubes, a second set of similarly disposed superheater tubes passing through the middle row of said enlarged smoke tubes, an end connection in the smoke box for said superheater tubes, a third set of similarly disposed superheater tubes passing through the top row of said enlarged smoke tubes, an end connection at the back wall of the boiler between the two



upper sets of superheater tubes, and a superheated steam header in the smoke-box connected with said third set of superheater tubes. Five claims.

922,365. SUPERHEATER FOR LOCOMOTIVES. SAMUEL M. VAUCLAIN, OF PHILADELPHIA, PA., ASSIGNOR TO BURNHAM, WILLIAMS & COMPANY, OF PHILADELPHIA, PA., A FIRM.

Claim 1.—The combination with a boiler having a smoke-box, of a stack connected to the smoke-box, a superheater made in two sections, respectively, mounted on opposite sides of the smoke box, with deflecting means mounted between said sections, and a device for ad-



justing said deflecting means either to direct all of the products of combustion through the superheater or to force the products of combustion from the central tubes of the boiler to pass directly to the stack, while compelling the gases from the remaining tubes to pass through the superheater. Fourteen claims.

922,366. SUPERHEATER. SAMUEL M. VAUCLAIN, OF PHILADELPHIA, PA., ASSIGNOR TO BURNHAM, WILLIMS & CO., OF PHILADELPHIA, PA., A FIRM.

Claim.—The combination of a superheater adapted to be mounted in the smoke-box of a locomotive boiler, consisting of upper and lower headers and connecting tubes, the upper header having a tube plate and a recessed casting having integral partitions, and having a tubular extension communicating at the forward end with one of the cavities formed by the partition, and at the other end adapted to be coupled to the steam supply pipe leading from the boiler. One claim.

922,426. ARTICULATED LOCOMOTIVE. GEORGE W. HENRY, JR., OF PHILADELPHIA, PA., ASSIGNOR TO BURNHAM, WILLIAMS & CO., OF PHILADELPHIA, PA., A FIRM.

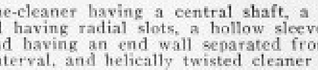
Claim 2.—The combination in an articulated compound locomotive, of a forward and a rear frame pivoted together, a boiler carried by and rigidly secured to the one frame and overhanging the other frame, a frame secured to the underside of the boiler and having a socket therein, a carrier having a ball at its upper end adapted to the said socket, a yoke to which the carrier is pivoted, a saddle carrying the yoke, and springs supporting the saddle. Eight claims.

922,871. SMOKE-CONSUMING FURNACE. PATRICK JOSEPH FLANAGAN, OF NEW ORLEANS, LA.

Claim.—In a furnace a bridge wall a transversely extending air distributing chamber in the brickwork of the furnace at the front thereof, and provided with a plurality of hollow nipples on its inner face, a plurality of hollow grate bars engaging the nipples at their front ends, and supported on the bridge wall at their rear ends, said bars having a plurality of openings in their upper faces and provided with outlet openings at their rear ends on the under sides thereof, and closures for the openings. One claim.

922,999. FLUE-SCRAPER. WILLIAM APPENBRINK, OF QUINCY, ILL.

Claim 3.—A flue-cleaner having a central shaft, a forward prismatic head, a rear head having radial slots, a hollow sleeve surrounding the prismatic head and having an end wall separated from an end wall of the head by an interval, and helically twisted cleaner blades having flat



forward end portions lying adjacent to the lateral faces of the prismatic head between the same and said sleeve, and having right angle terminations located in said interval, said blades having radially movable rear end portions having each an axial radial relation to said shaft and engaging a slot of the rear head. Three claims.

THE BOILER MAKER

AUGUST, 1909

A UNIQUE FRENCH ELECTRIC-HYDRAULIC RIVETER.

BY FRANK C. PERKINS.

In a boiler shop where electricity is the only power available, and it is desired to use an hydraulic riveter, the combination machine herewith illustrated would undoubtedly prove useful. Machines of this type are widely used in France, at the present time, and it is understood that some excellent results are obtained with them.

The pump forms a part of the machine, and no accumulator is utilized, the riveters being self-contained. The U-shaped frame carries a cylinder at its outer end containing a ram or piston. The motor is so mounted that its armature drives a bevel-gear wheel, which acts as a nut around a screw, forcing it with the plunger into the pump or hydraulic cylinder. A reservoir is provided, into which the water or oil is conveyed by a pipe connecting with the pump cylinder. There is a cock provided on the inside of the reservoir and controlled by a handle, so that the fluid is admitted to the top of the ram.

As the ram is forced downward to drive the rivet between the dies, it carries with it a recoil rod which is surrounded by a heavy spring. As soon as the pressure is released the ram is thus carried back to its former place.

As noted in the drawing, when the motor is started by throwing down the controlling handle, a brake is released and a shaft is turned, on which are mounted two adjustable cams, throwing them into a position to engage the plunger stop. When the ram and the plunger have been forced to the point desired, a roller engages the lower cam and throws the controller handle back to the normal position, thus applying the brake automatically. The controller handle is raised in order to return the ram, and this releases the brake again and reverses the motor so that the plunger is withdrawn from the pump cylinder. The water then flows back from the ram through the pipe connected with the pump cylinder as the ram

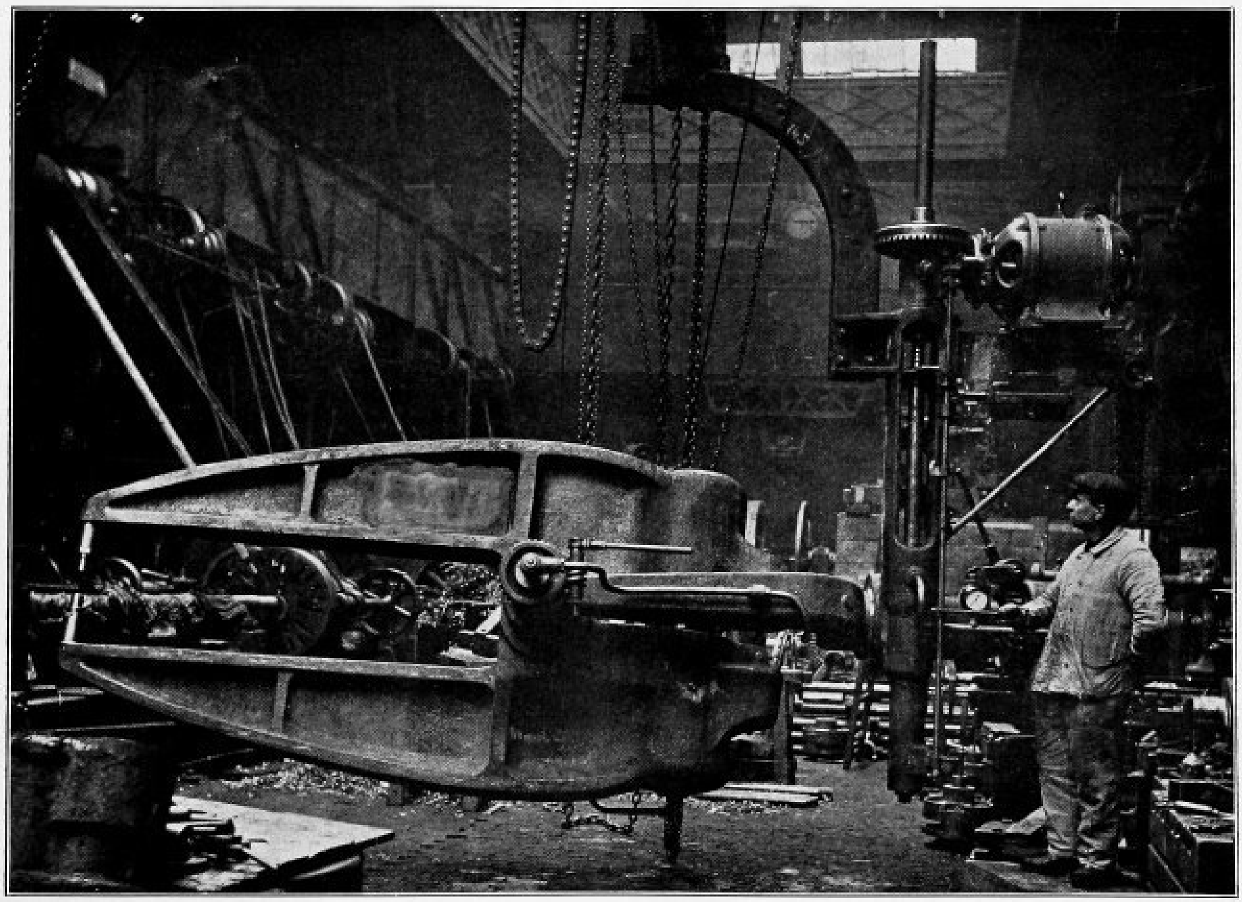


FIG. 1.—LARGE SIZE ELECTRIC-HYDRAULIC RIVETER USED IN FRENCH BOILER SHOPS.

is drawn up by the spring. There is a gage provided which shows the pressure at any instant, and the whole equipment may be handled by an overhead traveling crane, as indicated in the illustrations.

A large macine of this type is shown in Fig. 1. This riveter has movable jaws, with the plunger mounted near the bearing. There is a suspension yoke on the riveting frame, this suspension yoke being mounted above the motor gearing in the types shown in the illustration, while a ball-bearing thrust collar is provided on all of the riveters, reducing the friction on the gear nut driven by the electric motor.

PUTTING A HALF SHEET ON THE BOTTOM OF A 66-INCH BY 16-FOOT HORIZONTAL TUBULAR BOILER.

BY HENRY MELLON.

The front course of this boiler was a dry sheet 18 inches, the length of the old sheet from the front head center of rivet holes in the flange was 7 feet and the dry sheet 18 inches, making the course 8 feet 6 inches long and 66 inches diameter, all in one sheet. There was one seam in this course, lapped

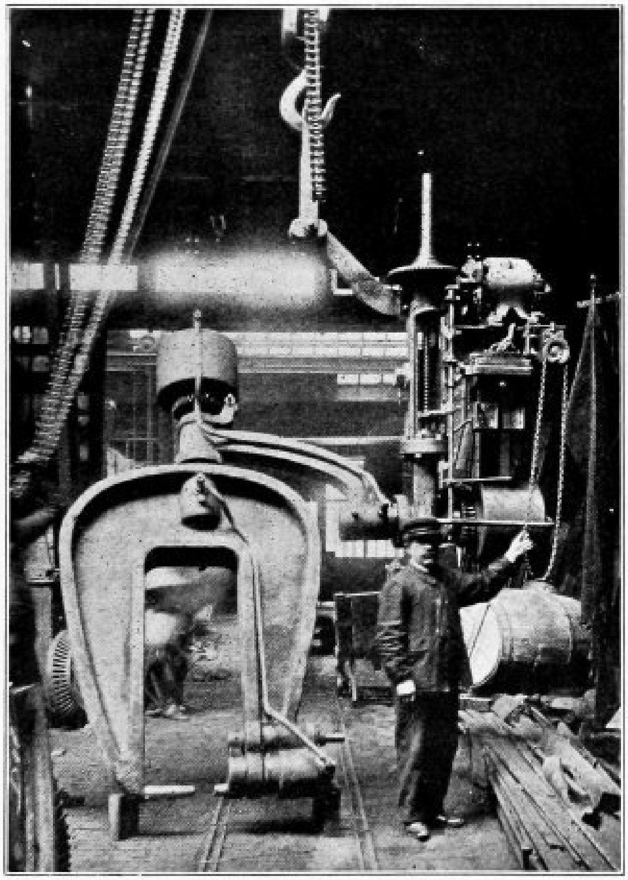


FIG. 2.—PORTABLE ELECTRIC-HYDRAULIC RIVETER.

and double riveted. This seam was just a few inches up above the quarter of the course on the right-hand side of the boiler. The sheet was badly bulged and cracked over the fire. The engineer wanted this old sheet cut off at the seam on the right-hand side, as I have mentioned, and this to be done by cutting out that seam of rivets, also on the left-hand side, to cut it off one-quarter way up, making a half course. He wanted it cut back to 5 feet 6 inches from the center of the rivet holes on the front head flange, which left 18 inches of the old plate on the old course.

I had the tubes taken out; they were 4 inches diameter by 16 feet long. I got two bars of iron, 3½ inches diameter and some 22 feet long, and put them through two tube holes at the sides of the boiler and blocked them up. Now the brick work was taken away back far enough so that the men could work. There was a rivet hole right on the bottom center of the front head, and also on the bottom center of the boiler shell. I snapped a center line on the old sheet on its center at the bottom, and 67⅜ inches from the center of rivet holes in the front head I drew a half-circle line for my new row of rivet holes. I drew a line to cut out the old piece on the half circle.

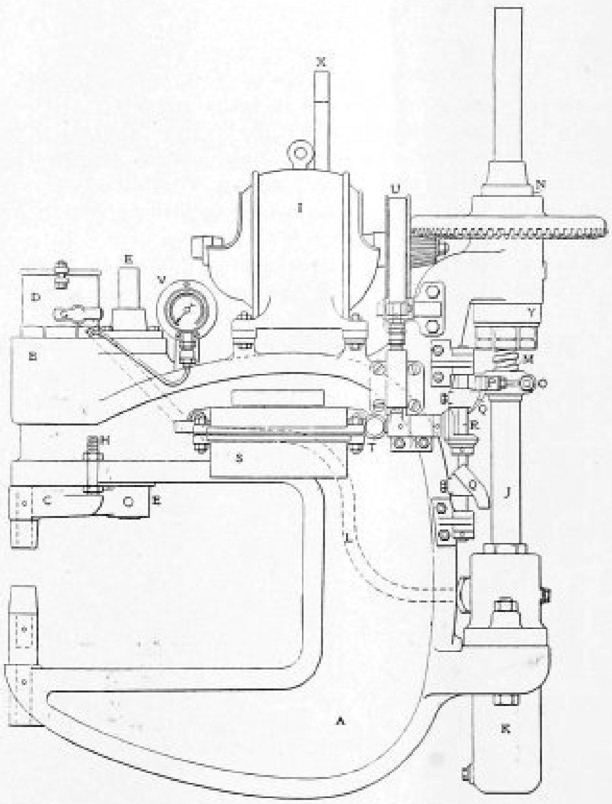


FIG. 3.—ARRANGEMENT OF ELECTRIC-HYDRAULIC RIVETER.

I then drew a line on the left side, on or near the quarter-center to be cut. Then I laid out the new double seam on this left-hand side for two rows of ¾-inch rivets. Now the men started and cut out the half sheet and screw-punched the new rivet holes; only some had to be drilled, because the screw-punch would not reach those on the upper side of the lapped seam.

It will be seen that the new half sheet will have to be laid out to a taper half course, because the new sheet will fit outside of the old sheet. But if the old sheet was cut off all the way back to its full length, then the new half sheet would not be a taper sheet. I wheeled the length of the old sheet, and found the length of the plate at that back end. I wheeled the length of the sheet at the front head and found the length of the plate at the front end. I measured the length off from the center of the rivet holes on the front head to the center of the rivet holes at the back girth seam, and got the width of the plate. I told the man not to bring the old sheet to the shop when it was cut off, as I did not want it. I counted the rivet holes in the front head and in the longitudinal seams, and got the number of holes that were wanted, then I went to the shop and laid out the half sheet in one sheet to the required taper, putting every rivet hole in it, punching the holes and beveling the calking edge, as the girth seam should look backwards.

The sheet was then rolled to a 33-inch radius, as the boiler was 66 inches in diameter, and sent out to the factory.

When the men were ready they put up the new sheet, and the foreman of the job told me that it fitted like a glove. The sheet was riveted and calked, the brick wall built up to the brackets, the 3½-inch by 22-foot iron bars taken out, and the tubes put in and set. The job was tested with cold water and found to be all right.

Putting a new half-fire-box in a 42-inch diameter upright boiler is about the same as putting on the new half sheet on the 66-inch horizontal tubular boiler. If a new fire-box is to be put in a 42-inch upright boiler, the water space being 2½ inches and the plate 5/16 inch thick, the inside of the fire-box would be 36⅜ inches diameter; but the inside diameter of the round ring would be 37 inches diameter, and the outside of the round ring to be 42 inches diameter; say the fire-box was 29 inches high from the bottom of the ring to the under part of the tube sheet, and the new part of the fire-box is to go up from the bottom of the ring 22 inches. This new fire-box plate would be a taper course, and to get the length of the plate in one piece, that is, if the boiler were lying on its side, first cut out the old piece on a good, true line up 22 inches from the bottom of the ring; cut out all stay-bolts and rivets, and take out the old piece, hit it a few raps in the center and it will curl up and it can be lifted out. Now wheel the inside of the fire-box up where it has been cut, or up 1⅛ inches higher. Now, if you are to put a new sheet in, and it is to be 5/16 inch thick, make the sheet that is going to be put in three and one-half or four times its thickness, shorter than what the wheel measures when wheeling the old sheet, and be sure that the wheel does not do any slipping or travel along a crooked line. If you have no wheel, get any round thing, say a cover of a lard can or a stove cover; they will be unhandy, but they will do. Now straighten out the old sheet for the bottom length; but it would be advisable to wheel the inside of the ring for that length of the sheet at the bottom and take off three and one-half or four times the thickness; four times makes a loose fit and is all right for such a job. Learn to get the lengths by a wheel, as it is quicker and more like a mechanic's job.

Now this sheet will have to be centered and the right height laid off along the center line, and as the part that fits to the round ring is the longest by about 2 3/16 inches, there is to be an arch made on each long edge of the plate. This is the so-called camber. It would take too much space to explain how to find those lines for the camber, but once one learns this camber lining then it is possible to lay off the full length of the proper size on each half of the center line.

Begin on the center line in the middle of the sheet and lay out the proper length from each side of the center and draw a line from one camber to the other, and the seam will be on those two lines. Now with a pair of dividers space off for a single seam in the fire-box one more hole on the longest camber than there is in the ring. If there were fifty holes in the ring and the new sheet was to be in one piece there must be fifty-one holes in the sheet; but it would be advisable to put the new sheet in two equal sized pieces, so that if there were fifty holes in the ring bar each sheet must have twenty-six holes on the camber that fits on the ring. Put the same number of holes up in the fire-box where the old sheet was cut off. The length of the camber for the job on the ring, if the job was to be in two equal sheets and on the line where the rivets will come, would be 57⅝ inches, and if fifty holes were in the ring then put twenty-six holes in the camber of 57⅝ inches. If the job is done with one sheet put fifty-one holes in the camber of 115¼ inches.

The length of the camber for the part of the sheet that goes up in the fire-box, if the job is in two equal sheets, would be 56 9/16 inches, and space off equally twenty-six holes in the new sheet. On the old sheet in the fire-box space off equally fifty holes, and be sure and have twenty-six holes on the exact half of the old fire-box sheet.

Now take pains in getting the door-rivet holes. Get a piece of thick paper, it should be as thick as the new sheet, but that cannot always be had. Mark the rivet holes from the door rings by laying the paper on the inside of the door ring, when it is cut out of the fire-box, but keep the paper up from the ring the thickness of the new plate, which is 5/16 inches. Do this by putting some pieces of wood between the paper and the door ring. Now put the paper on the new sheet, the new sheet and the paper to be straight, and the paper to lay tight and close to the new sheet.

Next space off the stay-bolts on a camber line on the two new sheets. There is no need of straightening out the old fire-box sheet. It would not be of any use except for the bottom row of holes, because the new sheet must be a taper course. Now put in the new two sheets and the door frame. Get a good, heavy wedge bar, with an iron handle some 30 inches long and 1¼ inches diameter, having the wedge part 8 inches long, 2½ inches wide, and the smallest point 1⅝ inches thick, and the thickest at the heel 2¼ inches thick. Now drive all the rivets in the round seam and in the two straight seams. The door frame can be moved either side and outwards, so as to give a chance to hold on to the few rivets that come back of it. Now put the door frame in its right place and put in the bottom ring. Drive the rivets in the door frame first, as it may crack. If all is well, then drive the bottom ring; put in the staybolts and drive them. Chip and calk the job. Calk the rivet heads on the door. It would also be advisable to calk the rivet heads on the bottom ring on repair work. Test the boiler and the job is done.

HOW BOILERS ARE RUINED.

BY WILLIAM OLSEN.*

Chemically pure water is unknown in its natural state. Water is a fluid composed of oxygen and hydrogen, in the proportions by weight of one part hydrogen and eight parts oxygen; it is a very powerful solvent, and in its course as a river, a brook or a spring it takes up and holds in solution more or less of the various minerals with which it comes in contact. Lakes and ponds that are fed by surface streams are likewise impregnated with impurities. The amount of these impurities varies according to the underlying strata of rocks on or through which the water passes on its way to the surface. Hence, in a section of the country where the rock foundation is of a limestone formation, the water in all wells, springs and streams will be heavily impregnated with sulphate and carbonate of lime.

Nearly all the minerals found in boiler feed-waters become sediment, due to the fact that these minerals cannot be evaporated. The most common of these impurities are lime and magnesia, in the form of a carbonate or sulphate; and, in brackish or salt water, chloride of sodium. Carbonates of lime and magnesia are soluble only when the water contains free carbonic acid. Well water contains more of these than river water. At 212 degrees the carbonic acid is set free, and the lime and magnesia, which were in solution as bicarbonates, being deprived of their solvency, become insoluble carbonates, floating around and through the water which is in agitation. Chloride of sodium, sulphate of lime, and the other salts held in solution are precipitated by the same process; but, owing to their greater solubility, much more evaporation is required.

Now, all these impurities are deposited on the lower sheets

* Supervisor of boiler cleaning, Motive Power Department, New York Central Railroad.

and tubes, mainly when the boiler is not used very hard, or when there is no steam going from the boiler when circulation has ceased. The moment these mineral particles touch the iron the heat bakes them; the carbonates forming a soft, granular and the sulphates a hard and crystalline scale. This settles to the bottom when everything becomes quiet in the boiler, and, as one can readily understand, displaces the water from the iron, and naturally receives the first heat when fire is again started. The scale immediately in contact is baked on the iron, while the remainder, by the agitation of the water, will be held in suspension and again be ready to settle when circulation ceases.

Now, it will be readily understood that the thickness of the scale increases day by day by the same process as at first until it becomes so thick and hard that, in order to generate steam, the fire must be forced, which results in a greatly increased fuel consumption and the ruinous overheating of the iron. We all know that incrustation and scale are very poor conductors of heat. Various estimates have been made of the loss of fuel due to the presence of scale in the boiler, the lowest of which is as follows:

	Percent.
For 1/16 inch	15
For ¼ inch	50
For ½ inch	120

and so on.

Still another matter of cost, resulting directly from the presence of scale, is that of repairs. When all these expenses are combined the amount chargeable to scale in the boiler is appalling. And it is not alone the additional expense for fuel and repairs that results from scale but the boiler is rapidly weakened.

Another serious cause of trouble in steam boilers is internal corrosion. This is not as common as incrustation, but, when it occurs, it is one of the most dangerous evils with which boiler owners and engineers have to contend. Its cause is now generally understood, and is looked upon by engineers, or the men in charge, as a matter of course; that is, that it must exist to a greater or less extent, on the theory that corrosion is rust, and that it is but natural for water to cause rust by coming in contact with iron in the presence of air.

Investigation, however, discloses some facts in connection with corrosion which will show that the evil is due to some other cause than the ordinary effect of water on iron. Internal corrosion is the most dangerous, for the reason that its presence is oftentimes not readily detected, the ordinary types of boilers being so constructed as to be difficult to properly examine internally. Internal corrosion is due to the presence of acids contained in the water or set free in the process of evaporation.

The proper care of steam boilers should be thoroughly understood by owners as well as by the engineers, for it is only by observation and close attention that economy of fuel and the durability and safety of the boiler are attained. Its neglect will mean poor steaming boilers, leaky flues and mud-rings, and when it comes to washing the boilers the scale will be found to have baked with one layer on top of the other.

In districts where the feed-water contains large quantities of carbonate of lime the very best remedy is to wash the boiler often. If dealing with a locomotive boiler, it is very important to remove all the wash-out plugs in order to get a stream of water inside and around the flues.

The greatest enemy that confronts all users of steam power is crust or scale in boilers. The manner in which incrustation or scale forms is commonly known. As has been explained in the beginning of this article the feed-water which must evaporate is not chemically pure, but contains elements, both in solution and suspension, that do not evaporate, but are left in the boiler, being deposited in the form of a hard crust or scale on the boiler plates. Incrustation is probably the greatest drawback in connection with the care and maintenance of boilers. It is a never-failing source of worry and expense; the cause of costly stoppages for scaling, chipping, etc., to say nothing of the danger arising through the impossibility of making a thorough examination.

Remedies for this have been brought forward in profusion, but with little benefit to the boiler, due, chiefly, to the fact that the start is invariably made from the attempted removal of the scale instead of preventing its formation. A partial removal of the scale is sometimes attained by the use of some of these remedies, but usually at the expense of the boiler—its life being shortened—and therefore the remedy is almost worse than the disease.

There is but one really safe method of eliminating this trouble, and that is, the boiler must be clean and retained so. This may seem almost impossible to those who are conversant with these difficulties, but prolonged practical tests have proved to the contrary; and by these tests the conclusion is reached that by the application, in *proper quantities*, of *carbonate of soda*—commonly known as "Soda Ash"—these difficulties can be overcome. But it must be remembered that in many cases, and for a long time, carbonate of soda has been used and incrustation still occurs. This must be admitted, but it is not sufficient merely to *know a remedy;* it is also necessary, in order to obtain satisfactory results, to know the proper proportion and the method of application, otherwise it is comparatively useless. Many are unaware of the proper function of soda ash in boiler water, but think only of its biting qualities as used in cleaning. To such an extent does this prevail that many engineers use even caustic soda. This is a serious error. Soda cannot bite off incrustation, but if it is added to the boiler water in proper quantities it will change what otherwise would become scale into a chalky mud, that will not deposit itself on the boiler plates, but will sink to the bottom of the boiler, where it can then easily be blown off or washed out.

Again, carbonate of soda has the useful property of neutralizing harmful acids that are present in most feed waters, and, consequently, prevents corrosion and pitting. It is, however, imperative to know the exact quantity of soda ash to add in order to obtain the desired results. There must be neither lack nor excess of quantity, the latter causing priming and foaming. In stationary plants, where feed-water heaters are used, it has been found that oils, etc., used for lubricating purposes, enter into the boiler to some extent, and if soda ash is used in excess it saponifies (changes to soap) the oils, and again through galvanic action corrosion will set in.

A Mysterious Boiler Explosion

A 400-horsepower Wickes vertical boiler at the plant of the Denver Gas & Electric Company, Denver, Col., exploded on June 15, killing four, injuring six, and causing a property loss estimated at $75,000. The boiler had been out of commission for several days for repairs, and the explosion occurred just before cutting in the boiler again after the steam pressure had been raised to about 150 pounds per square inch. The rupture occurred at the riveted joint between the bumped head of the lower drum and the shell of the drum. The drum was 8 feet in diameter, and the circular seam single riveted with 1-inch rivets spaced 2⅝ inches between centers. The shell plate was 9/16 inch thick, and the bottom head ⅞ inch thick. The shell plate ruptured between the rivet holes for almost the entire length of the seam. For the remaining distance the rivets sheared off. All calculations seemed to indicate that the boiler was amply strong for the pressure carried, and no signs of dangerous deterioration could be found.

A RIVETED JOINT PROBLEM.

The following question was asked recently, a review of which, together with the answer given, may be of interest to the readers of this journal: "Please give rule for pitch of rivets when the thickness of plates, diameter of rivets, and percentage of strength of joint are given. Assume, for example, ¼-inch plate, 11/16-inch rivets and 72½ percentage of strength of joint compared with the solid plate."

In calculating the efficiency of a riveted joint, there are two efficiencies considered: plate efficiency and rivet efficiency, the lesser one being taken as the efficiency of the joint as a whole. The efficiency depends upon the pitch of rivets, and it is possible to have two different pitches give the same efficiency of joint as a whole. Of course, by trial, a pitch can be arrived at that will give the same (or very nearly so) efficiency for both net section of plate and the rivets themselves; but, as a general thing, one exceeds the other by a small percentage, at least.

Now, in the example given, the efficiency is stated as 72.5 percent. This is the percentage of strength of the joint, as a whole, and it is also the lesser of the two percentages to be considered, but there is nothing in the statement of the question to indicate whether the 72.5 percent is the percentage of the net section of plate, or of the rivet section of the joint. It may be either, according as to what pitch be given the rivets, thus showing the possibility of two pitches to choose from when designing such a joint. Let us look into the matter and see what we can learn concerning it.

The rule for determining the strength of rivets in a given joint is stated thus:

$$\frac{a \times n \times S}{p \times t \times T} = e$$

in which a = area (sectional) of rivets used,
n = number of rows of rivets in joint,
S = shearing stress per square inch of rivets,
p = the pitch of the rivets in inches,
t = thickness of plate in inches,
T = tensile strength of plate in pounds per square inch section,
e = efficiency of joint, expressed as a decimal.

Applying this rule, or formula, to the problem in question, we have a statement like this:

$$\frac{.37122 \times 2 \times 38{,}000}{x \times .25 \times 50{,}000} = .725$$

in which x represents the unknown but desired pitch of rivets. We have made certain assumptions necessary to the operation of the problem, viz.: that there are two rows of rivets, as indicated by the stated efficiency of joint; that the shearing stress of the rivets is 38,000 pounds, and that the tensile strength of plate is 50,000 pounds.

By transposition of terms in the formula, and solving for the value of x, the statement will appear like this:

$$\frac{.37122 \times 2 \times 38{,}000}{.25 \times 50{,}000 \times .725} = x,$$

which, numerically, is 3.1, pitch in inches, when considering the rivet portion of the joint.

In order to find the percentage of strength of the plate section of joint, this formula may be employed:

$$\frac{p - d}{p} = e$$

in which p, as before, equals the pitch of rivets, d equals diameter of rivets (both in inches) and e the efficiency of plate section of the joint, expressed as a decimal. Applying this to our problem, we have:

$$\frac{p - .6875}{p} = .725$$

in which the value .6875 equals diameter of the rivet expressed decimally as a matter of convenience in the solution of the problem. By transposing the terms and working for the value of p, we have:

$$p - .6875 = .725\,p$$
$$p - .725\,p = .6875$$
$$.275\,p = .6875$$
$$p = \frac{.6875}{.275}$$
$$p = 2.5 \text{ inches.}$$

Arithmetically, it can be solved like this: $1.000 - .725 = .275$, and $.6875 \div .275 = 2.5$ or 2½ inches pitch required, when considering the plate section of the joint.

From the foregoing it can be seen that no positive rule can be given in relation to the matter, unless the statement also contains an additional clause designating the relation the stated efficiency bears to the problem. By a careful choice of rivet size and pitch, the plate and rivet efficiencies may be very nearly the same, and such a condition can only be arrived at by trial, as before observed.

A study of the foregoing may be of more than passing interest to those who have to do with such work, hence the excuse for the appearance of this little article.

Charles J. Mason.

LOCOMOTIVE BOILER INSPECTION.*

Your committee appointed to consider the proposed government regulations for the construction and inspection of locomotive boilers would recommend the adoption by the association of the following minute:

We, members of the American Railway Master Mechanics' Association, at our regular annual convention, June, 1909, considered, among other subjects, Senate Bill No. 236, presented by Senator Burkett to the sixty-first Congress, "To promote the safety of employees and travelers upon railways by compelling common carriers by railway to equip their locomotives with safe and suitable boilers and appurtenances thereto."

It is the opinion of the association that such a law is entirely unnecessary and will not promote any greater safety of operation, for the following reasons:

First. That the railways maintain efficient systems of inspection and tests of locomotive boilers and appurtenances under carefully prescribed rules, which are prepared to best meet general and local conditions, the railways having the greatest possible interest in the thoroughness of this protection.

Second. Experience covering a period of many years has shown conclusively that such failures of locomotive boilers as have occurred would not be eliminated by the proposed law, as investigation has shown that they were not due to defective design, construction, weakness or lack of proper appurtenances or periodical inspection.

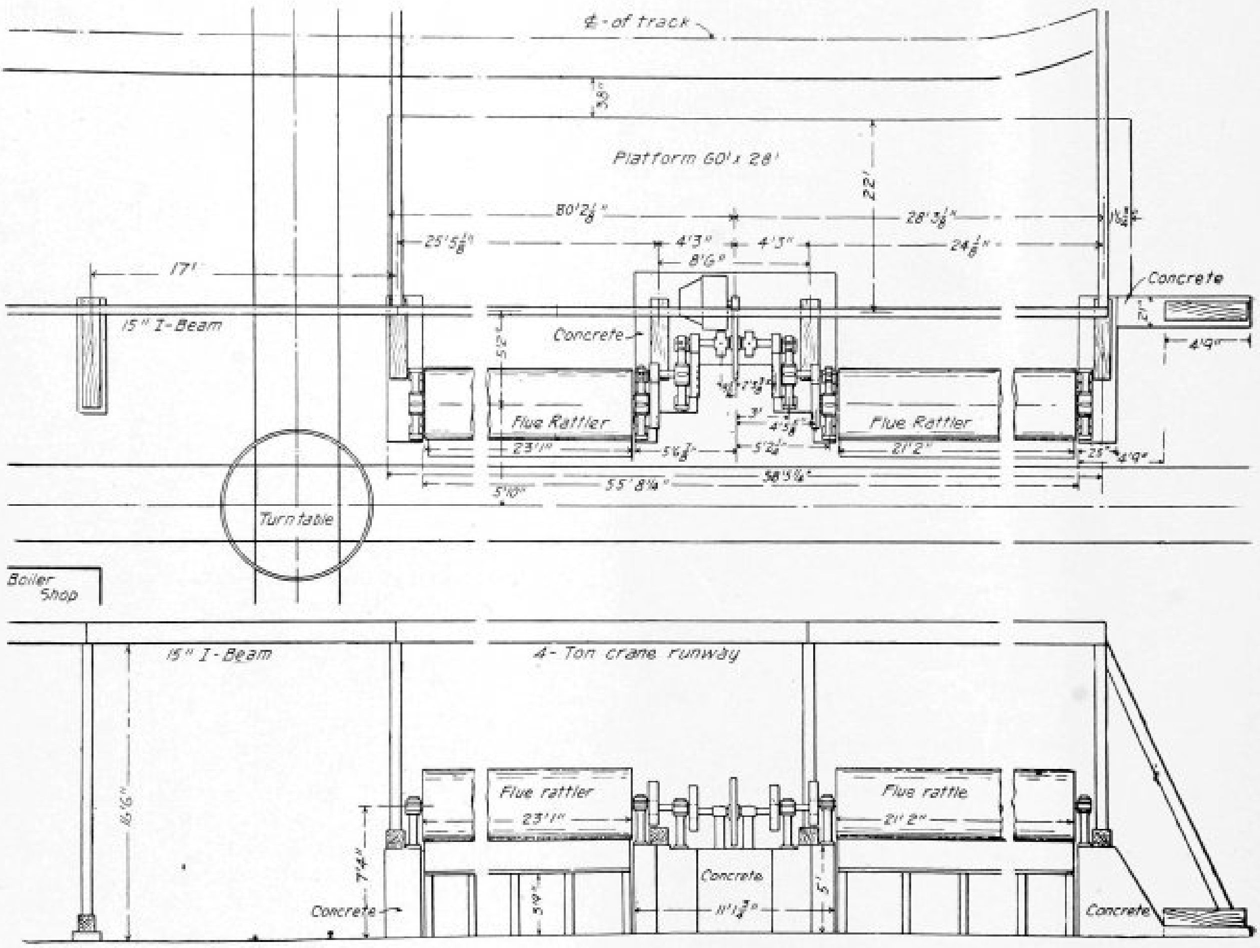
We would, in addition to the above, recommend that the subject be given full consideration by the executive committee.

* Special committee report presented at the annual convention of the American Railway Master Mechanics' Association, Atlantic City, N. J., June, 1909.

LARGE CAPACITY, HOME-MADE FLUE RATTLER.

In connection with its new boiler shop, the Illinois Central Railroad has a flue rattler which has no equal in the country. Mr. G. M. Crownover, superintendent of the Burnside shops, worked out the design, and its success does him credit. The accompanying drawings illustrate the machine only partially, but the general principle will be at once understood.

The tubes are brought from the boiler shop on narrow-gage push cars on the track shown in the plan view. When opposite the platform of the rattler, the 4-ton yard crane picks them up by means of chains and lifts them slightly above the level



PLAN AND ELEVATION OF FLUE RATTLER, ILLINOIS CENTRAL RAILWAY.

of the rattling cylinder. As fast as needed the operator drops them into the cylinder, and after they are rattled they are rolled onto empty cars on the other side.

The capacity of this machine is so great that it does not need to be run more than 4 hours a day to rattle the tubes of all the engines handled in the shops, whereas the rattling of the tubes in the old way was considerable of a problem and required the services of several men night and day. One man only is necessary to operate Mr. Crownover's machine; he stands on the platform between the two cylinders where the motor is located.

The details of the cylinders and framing show heavy construction throughout, and the foundations of concrete eliminate a great deal of the vibration. It might be added that the lime from the tubes falls into pits beneath the cylinders, where it can be easily reached.—*The Railway Master Mechanic.*

HOW TO RETUBE A HORIZONTAL TUBULAR BOILER.

BY HENRY MELLON.

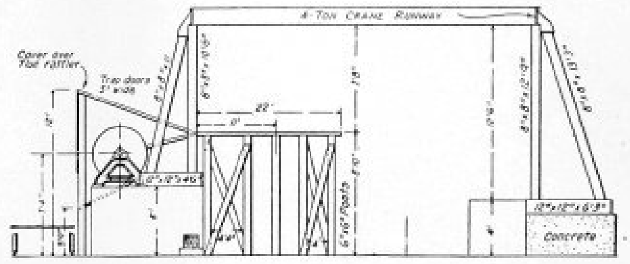
The writer and one other boiler maker went to a factory, taking with them two hand chipping hammers and a few hand cape-chisels and flat chisels and two tin lamps for lard oil, and one 3-inch tube roller and two beading tools. The boiler to be retubed was a horizontal tubular boiler, 48 inches diameter with fifty tubes 3 inches by 15 feet. There was a 4 by 6-inch hand-hole in the front and back ends.

I started at 8 A. M., and split the tubes at the center of the bottom row at the back end, and chipped the beads off at the front end, one row at a time. I drove the tubes with a blow or two with my chipping hammer back towards the back end about 1 inch, then the man at the back end hit them back to me at the front end, and I guided them out of the hand-hole. I had the fifty tubes out of the boiler at 11.30 A. M., or in three and a half hours, and with only a few hand tools at that.

The new tubes were there at the plant. We put them in the holes, hammered over the edges for a beading lip, and I started the other man rolling them at the front end. I then went to the back end and chipped off on an average of 3/8 inch from each tube, and beaded them as I cut them off, the other man rolled the front end as fast as I could cut and bead the back end. Then I rolled the back end and the other man beaded the front end, so that we both finished at the same time. I tested the boiler and finished the job in twenty hours. It was a contract job.

Splitting the ends of tubes is the full secret of getting them out quickly, although the time required depends on the kind of a job. For example, suppose it is necessary to take one 3½-inch by 16-foot tube out of a 60-inch diameter horizontal tubular boiler, the tube being up in the left-hand corner, four rows down from the top row. It is required to take the tube out and put in a new one; the work being done by a right-handed man.

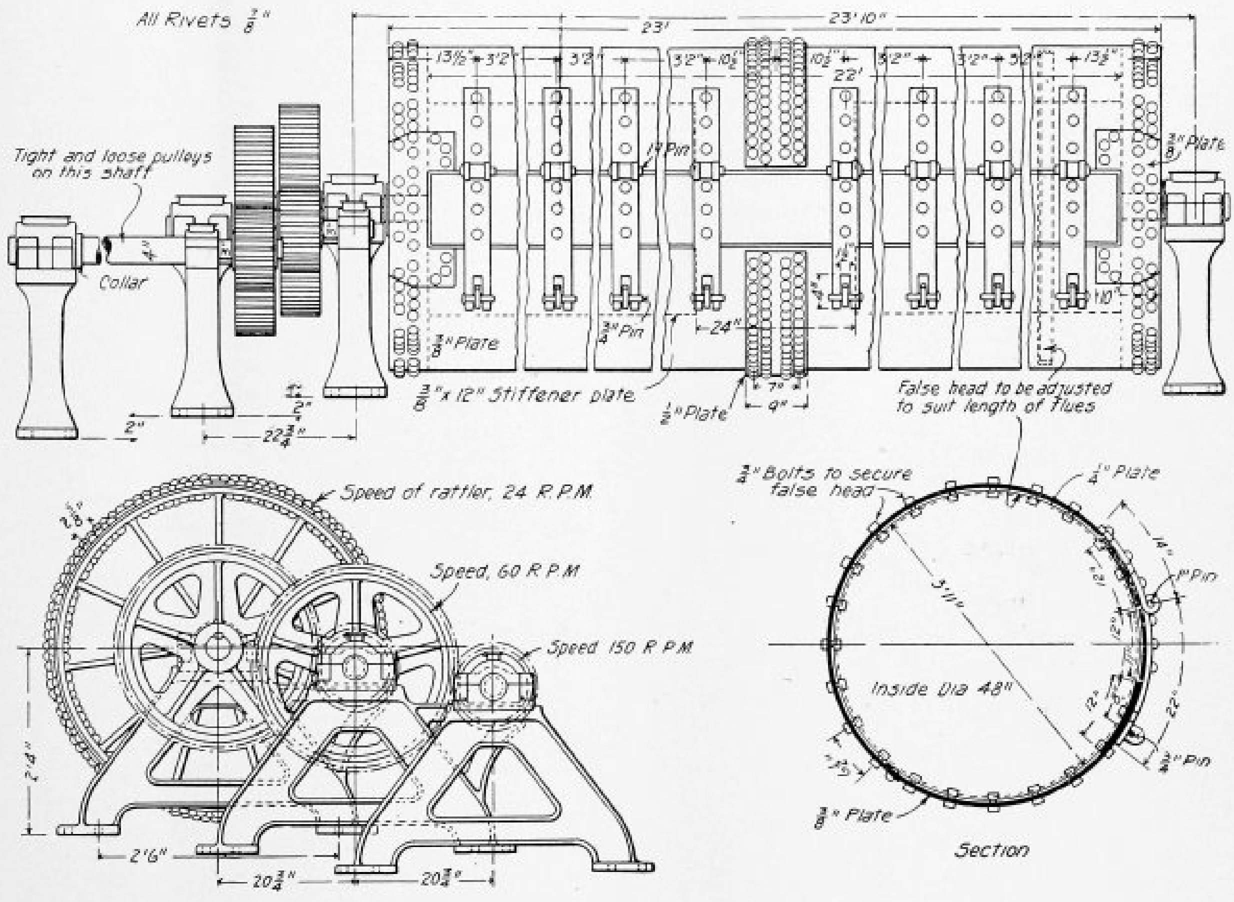
First chip off the bead from the tube at the front end, and chip it off good and flush. Now take a very thin diamond-point chisel (if one is a jobber he will not go away without such tools), and cut a V-shaped piece out of this end of the tube; make it ½ inch wide and 2½ inches long, but do not let the diamond point go clear through the old tube. Be sure and cut this V out in the most convenient part of the tube, so that you can work up the piece. Now take a thin cape-chisel and hit it in under the V-piece, and drive the V-piece away back for the 2½ inches; this is a clean cut with no burr edge on it on the water side. Drive the cape-chisel in at the sides of the tube,



END ELEVATION OF FLUE RATTLER.

light chip from the tube hole, and then file the hole a little larger. Then get the fireman to go to the back end and push the tube out to you, being careful not to let the bar of iron drop into the boiler. All this is easy to do, and it doesn't take long to do it.

When the new tube goes in get a piece of an oil barrel iron hoop, about 5 inches long for a 3½-inch tube, and cut the two



DETAILS OF FLUE RATTLER, ILLINOIS CENTRAL RAILWAY.

and see that no lump goes inwards. This leaves the tube loose at that end. Now go and chip off the bead at the back end, and if you think well of it split the back end a little. It is well to do so, as it will come out easier at the front end when it comes to that place.

Next put a piece of wood or a bar of iron, some 18 or 20 inches long, in the back end of the tube, as the tube is in an outside row, and would otherwise fall down in the boiler. Now hit the tube out, and go to the front end and pull it out. If there is a lot of scale on the tube it will stick. In that case get it out about 1 inch and cut off that inch, and then push the tube back into the boiler, but put a bar of iron in the tube at the front end, the same as at the back end. Now skin off a

ends off cornerways, which will make one length of this hoop 3½ inches long. Scarf this piece and drive it in between the tube and the tube sheet. If that doesn't make the tube tight put another piece in alongside it. Now hammer over the edge of the tube, and expand it and go to the back end and chip off any unnecessary length and expand and bead the tube. Bead the front end and the job is done.

In taking out a full set of tubes in this boiler, if there is a hand-hole front and back, split each tube at the back end with a fairly stout cape-chisel; have a man at the front end chip off the bead and hit the tube to the back end just about 1 inch. Now let the back-end man hammer in the beading with a 5-pound hammer (a light one is no good), and then he can knock the tube to the man at the front end and out through the front hand-hole. If there is no hand-hole at the back end then the tubes must be split at the front end, as the back hole would be a good advantage in dodging from one to the other.

As another example, suppose one tube must be taken out of an upright boiler, 60 inches diameter, the tube being 72 inches long from the crown sheet to the top head and 2 inches diameter, located in the outside row. There is only one man to do the job, with no help whatever except his tools, and the tube is thickly coated with scale. First cut off the bead at the top, and then split it down 2½ inches in a V-shape. Have the V about ½ inch wide at the top. Now knock this V-piece down its full length, and then gather in the tube so it will come out. Now go down to the fire-box and chip off the bead and split the tube in V-shape up about 1½ inches, and curl up this end, then get a piece of wire about ⅛ inch thick and 6 inches long, and make a hook of one end and an eye of the other end. Now get a piece of line, like a clothesline, some 8 feet long, tie the wire to the line and lower the hook and line down from the top of the tube, and put the wire hook into the piece that is curled up at the bottom of the tube. Now hit the tube up about 1 inch. Go up on top and tie the line to a pipe, or something, so as to hold the tube up. Now cut off the 1 inch and then lower the tube on to the crown sheet, but do not let it fall into the water leg. Chip a little out of the hole and then fille it, and then pull the tube up and put in the new one. This method is useful only when there are a few tubes, and is an easy way when a man is alone.

The First Multitubular Boiler.

According to the *Valve World* the success of Stevenson's locomotive, the Rocket, in 1829, and of Fulton's steamboat, the *Clermont*, in 1809, was due in a large measure to the multitubular boiler invented by Nathan Read, of Massachusetts. Read's first model consisted of a vertical multi-tubular boiler having seventy-eight tubes arranged in circles. The outside rows were open top and bottom. The inner rows were shorter and open only at the top. The space thus left at the bottom served as a fire-box.

MECHANICAL STOKERS.*

The Victor, Crosby, Strouse and Hayden stokers were described at the last meeting of the association. The committee has been advised that further development and extended use of the Victor and Crosby stokers have ceased. It has investigated, as far as possible, all types of mechanical stokers which have reached an interesting state of development, but, with the exception of one stoker, has been unable to procure any figures of tests.

The Strouse over-feed stoker, as manufactured by the American Automatic Stoker Company, is now said to be at a marketable stage, twenty-two of them having recently been furnished to the Chicago & Alton and two to the Iowa Central. It is hoped that in the near future there will be available data covering practicability and efficiency; but as yet the committee has been unable to procure any data of value on the subject, the tests, apparently, having been more on the order of proving the mechanical possibility of the apparatus and observing the effect on the reduction of black smoke.

The Pennsylvania Railroad is developing an under-feed stoker of its own design, which so far seems to give promising results, but there are no data at hand showing its performance. This stoker uses coal up to sizes of 4 or 5-inch cubes, and requires no change of the locomotive other than the application of a special form of grate. The application of the mechanism is such that the fire door is in no way obstructed, so that hand firing may be resorted to on the road without any change or removing of apparatus. At present the coal is shoveled from the tank to the hopper of the stoker, but it is intended to install some means of mechanical conveyance.

The Barnum under-feed stoker of the Chicago, Burlington & Quincy requires screenings of 1½ inches. The application of this stoker is such that hand firing cannot be accomplished without changes such as to require the work to be done in the shop. The installation of the stoker necessitates the removal of the grates, extension of the back frames and the remodeling of the ash-pan and draft appliance in the front end. The distribution of coal in the fire-box is such as to seldom necessitate raking of the fire. With this stoker, also, the coal is delivered to the hopper by hand, but it is the intention to make this automatic later.

The Black or Dodge stoker, which is being developed on the Erie, is of the over-feed type. The only change to the locomotive necessary to the application of this stoker is the replacing of the fire-box door by a specially designed box-shaped door, in the center of which is a pivoted shelf, which can be tilted to any angle to the plane of the fire by means of a lever at the front of the door. Two four-blade gears, revolving at about 250 revolutions per minute, on the top of the shelf, spray the coal over the fire as it falls on the shelf from the hopper, which hopper is attached to the top of the door and forms a part thereof. The distribution of the coal is controlled by tilting the shelf, and thus directing the spray of coal to any desired part of the grate. The whole operation can be observed through peep holes in the fire-door. The coal is conveyed to the hopper by a worm conveyor extending from the forward end of the coal space in the tank to the hoppper, coal being delivered to this worm from the full length of the coal space by means of another worm. In order to fire by hand, the front worm conveyor is thrown back on its hinge and secured to the tank; the door requires no change, being all in one piece and hinged on the original fire-door hangers; it can be operated similarly to the ordinary door. The size of coal for which this stoker is adapted is everything that will pass through a 3 or 4-inch screen.

A number of tests have been made of the Hayden automatic stoker, in use on the Erie, condensed tabulated results of which follow. While the results of the test were not favorable to the stoker, its possibilities were felt to be such as to warrant the construction and placing in service of five more. It is evident that the operation of the stoker will be best shown by comparison of the equivalent evaporation per pound of combustible and the combustible-hours per ton-mile, which latter item takes into consideration the time in which the run is accomplished. From the data it is seen that engine 1,627, which made the first test in April, 1907, showed .734 percent more equivalent evaporation per pound of combustible with the stoker, while engine 1,653 in the second test, made in April, 1908, showed 11.16 percent less. The fuel used with engine 1,627 was run of mine, the lumps being broken to about 3-inch size by the fireman, to suit stoker requirements; whereas engine 1,653 was furnished with coal passed through a 3-inch screen, resulting in the latter containing a very large proportion of fine coal, which would affect the evaporation per pound of combustible. While the combustible-hours per ton-mile takes in, to a certain extent, all the varying conditions which make it impossible to obtain two similar results of like tests, it is of fairly good comparative value. With engine 1,627, the stoker showed a loss of 17.02 percent, while with engine 1,653 the combustible-hours per ton-mile was only 8.7 percent greater with the stoker.

Although the stoker might show an increase in fuel con-

* Report presented at the annual convention of the American Railway Master Mechanics' Association, Atlantic City, June, 1909.

sumed per ton-mile, as the provision of automatic firing would induce the engineer to work the engine harder, since firemen's labor and endurance were not concerned, it was felt that the time on road would thus be reduced and economy shown in fuel-hours per ton-mile when used as a basis of comparison, but the results were not as anticipated.

The committee directs attention to the fact that automatic stokers are in their infancy, and it should be realized that efficiency over hand firing could hardly be expected at such an early stage. It furthermore feels that the tabulated results hold out great hopes for the future, particularly as the question has been taken seriously by a number of railways.

The gradual retirement of old cars with structural weaknesses, and the advent of improved draft gears and triple valves, render it possible to increase train length without resultant troubles from trains parting; consequently, it is reasonable to assume that the average tractive power of locomotives will increase. It is within possibilities, therefore, that the increased fuel consumed per mile will render it advisable to provide mechanical means for firing locomotives in order that they may develop a high sustained tractive effort and render the service attractive to men who possess qualifications to become successful locomotive engineers.

A successful automatic stoker should render locomotive firing more attractive, raise the standard of the service, permit close attention to economic handling of fuel and reduction of black smoke, enable firemen to become better acquainted with the general duties of a locomotive engineer, and reduce tube and fire-box troubles.

TEST ON HAYDEN AUTOMATIC STOKER ON ERIE RAILROAD.

Engine	No. 1627	No. 1653
Size of cylinder	22 x 32 inches	22 x 32 inches
Number of flues	380	380
Size of flues	2 inches	2 inches
Size exhaust nozzle	$4^{15}/_{16}$ inches	$4^{15}/_{16}$ inches
Heating surface	3,358 square feet	3,358 square feet
Grate area	54 square feet	54 square feet
Kind of valve	Richardson balance	Richardson balance
Type of boiler	Wagon top	Wagon top
Type of firebox	Wide	Wide
Rated steam pressure	200 pounds	200 pounds
Diameter of drivers	62 inches	62 inches

	Firing on 6 Trips.		Difference in % Hand Firing.	Firing on 8 Trips.		Difference in % Hand Firing.
	Hand.	Auto.		Hand.	Auto.	
Average running time, hours	4.756	5.052	.....	5.884	6.26	.....
Number of miles in run	139.7	139.7	.....	139.7	139.7	.....
Average ton-miles	171,942	160,943	.....	244,382	261,035	.....
Ton-miles per hour	36,150	31,800	.....	41,600	41,900	.....
Average steam pressure	196.5	191.7	.....	193.4	195.4	.....
Fuel consumed, pounds	20,275	20,688	.....	21,709	23,287	.....
Water evaporated, pounds	114,816	126,410	.....	151,175	146,562	.....
Do., per lb. fuel, lbs	5.687	6.0998	7.26	7.007	6.314	9.88
Do., per lb. fuel, per hour	1.196	1.207	.92	1.196	1.011	15.47
Weight of ash	698	527	.....	2,134	2,040	.....
Percent ash	3.46	2.53	.....	9.82	8.74	.....
Pounds combustible consumed	19,577	20,161	.....	19,575	21,248	.....
Pounds water evaporated per pound combustible	5.887	6.261	.....	7.77	6.92	.....
Average temperature feed water, ° F.	39.8	41.24	.....	67.63	67.6	.....
Pounds water from and at 212° F. per pound combustible	7.632	7.688	.734	9.387	8.339	11.16
Rate combustible per square foot heating surface, per hour, pounds	1.003	.878	.....	1.102	1.112	.....
Pounds water per hour from and at 212° F. per pound, combustible	1.538	1.525	.845	1.64	1.335	18.59
Rate combustible per square foot grate area per hour, pounds	63	55.2	.....	68.55	69.18	.....
Eq. evaporated, per square foot heating surface	8.97	9.15	.....	9.57	8.46	.....
Pounds coal used per ton-miles	.1179	.1285	8.99	.0889	.08940	5.63
Pounds water evaporated, ton-miles	.686	.821	.....	.619	.562	.....
Fuel-hours, per ton-mile	.5609	.6494	15.77	.528	.5602	7.15
Combustible hours ton-mile	.5637	.6597	17.02	.472	.513	8.7

NOTE.—Fuel and water consumed during detentions are not included.

DISCUSSION ON MECHANICAL STOKERS.*

G. R. Henderson.—When this subject was discussed last year, we called attention to the fact that a great many of the large modern locomotives were not giving returns in hauling capacity commensurate with the size and cost of the locomotive, apparently on account of the impossibility of one fireman getting sufficient coal into the fire-box, and we advanced the argument that an automatic stoker would be necessary in order to realize the full benefit of such large locomotives. Since the last meeting we have had occasion to estimate the probable advantages on a large Mallet locomotive of an automatic stoker, and we thought that the figures might be interesting to the members of this association.

The division to be covered by this locomotive was 100 miles in length, against the traffic, of which there is a 0.5 percent compensated up-grade 40 miles long, and the remaining 60 miles are practically all down-grade. The locomotive upon which our figures were based was of the Mallet type, having a tractive force 65,000 pounds, which would enable it to haul at slow speeds 4,200 tons up the 0.5 percent grade, on which our figures were made, ascending the grade at 6, 10 and 15 miles per hour. It was assumed that one fireman could handle 3,000 to 4,000 pounds per hour throughout the 40 miles up-grade, or that two men, by working in relays, would be needed to supply 6,000 to 8,000 pounds an hour, but for quantities over this a mechanical stoker would be necessary. As the grate area of this locomotive is 78 square feet, it will be seen at once that it would be possible to burn from 12,000 to 15,000 pounds of coal per hour if found desirable or necessary. In making these figures, the following units were assumed: The actual time between terminals would be 20 percent greater than the running time, this allowing for lay-overs, etc.; the down-hill speed would be 30 miles an hour; the cost of the coal was taken at $1 per ton, and of water at 5 cents per thousand gallons. Allowances were also made for repairs, renewals, pay of enginemen, handling at terminals and interest on investment. It was considered that there would be five hours consumed in turning the engine at the terminals of the division, and the cost of train supplies, car repairs, pay of trainmen, etc., was included, so that the figures show the actual cost of operating the train, but, of course, do not cover the general expenses of superintendence, maintenance of track, buildings, bridges and other data except the usual train operation, which figures really comprise only about 40 percent of the total cost due to all expenditures of the road. The cost was figured out for the total movement on one trip, also for 1,000-ton miles of train back of engine, including the weight of the cars and ton miles per hour performed by the engine, with the allowance of five hours for turning, as above mentioned. These figures, therefore, enable one to see at a glance the variation in cost and capacity due to one or two firemen, or to a mechanical stoker. The figures are given below:

Speed, up hill m. p. h.	6	10	10	15	15	15
Cost, movement, per trip	$79.93	$82.35	$62.18	$87.05	$67.00	$50.38
Cost, per 1,000 ton-miles	.19	.20	21	.22	.22	.25
Ton-miles, per hour	27,300	34,400	24,600	38,000	28,300	19,000
Weight of train, tons*	4,200	4,200	3,000	4,000	3,000	2,000
Method of firing	1 fireman	2 firemen	1 fireman	Stoker	2 firemen	1 fireman

* Train back of tender.

It is seen, therefore, that by far the greatest amount of work done by the engine is with the use of a stoker and running up hill at a speed of 15 miles per hour, the assumption being in this case that there would be 15,000 pounds of coal burned per hour while running up the grade. The cost per 1,000-ton miles is less than if we attempted to run with half

* As reported in the daily edition of the *Railroad Age Gazette*.

the load at the same speed up hill with only one fireman, and it is only 3 cents greater than if we went up the hill at 6 miles an hour with a single fireman. At ten miles an hour two firemen would give nearly the same capacity of the locomotive and at somewhat lower cost, but it is rather uncertain whether two firemen can be managed satisfactorily on a locomotive, and where a large amount of traffic is to be gotten over the road, the advantage of being able to push the engine to its full capacity and at a fairly high speed is shown without any uncertainty.

At 15 miles an hour, considered economical speed for general operation, one fireman could handle 19,000-ton miles at a cost of 25 cents, two firemen 28,000-ton miles at a cost of 22 cents, and the stoker 38,000-ton miles per hour at a cost of 22 cents. You will see, with a slight additional increase or cost of stoker over one man at slow speeds, a much larger amount of ton miles can be attended to, and at speeds of 15 miles an hour the cost of the stoker is considerably less than that of one fireman, and double the amount of ton mileage can be made with the engine.

C. E. Gossett (Iowa Central).—I witnessed the action of the stoker of the Chicago & Alton, and wish to state frankly that I consider it beyond the experimental stage so far as the principle is concerned. On the trip that I made out of Bloomington the consolidation engine was rated at 2,800 tons. The engine on this day had 3,300 tons, or 500 tons more than the rating, using mine-run Illinois coal. The fireman experienced no trouble whatever in keeping the engine hot; in fact, he was at no time hurried about his work. The engine made an average speed of 17 miles an hour for a distance of 88 miles. In that 88 miles the fireman moved his grate slightly three times. On arriving at the terminus the fire was apparently as good as it was when we started, and the variation of the steam pressure throughout the trip was not to exceed 4 pounds at any place. Another important factor to be considered in using the stoker is when the engineer started to shut off for drifting or station stop, on account of the fire being in such perfect condition, there was very little blowing off, and, as stated before, when we arrived at Joliet, after being on the road about seven hours, the fire appeared to be in such condition that it could go on several times that distance without cleaning. I consider the stoker a complete success.

John Tonge (M. & St. L.).—I was with Mr. Gossett on the trip referred to, and I think he omitted the most important part of the statement which he should have made; that is, that the stoker did not receive any repairs for a month, and that the determination was to let it run until it would quit the service, to see what would be the trouble, and how long it would run. The trip we made was successful in every respect. The steam gage did not move. As Mr. Gossett said, the normal rating was about 2,800 tons, and they had 3,300 tons for that trip. I am positive that is about 200 tons short of what the engine could have hauled. They had increased the nozzle from 5¼ to 5¾ inches, and the traveling engineer insists on another ¼ inch. I was not looking much at the matter of coal saving under the conditions referred to. While it is a fact that even firing must necessarily save coal, when you can increase your tonnage 500, 700 or 1,000 tons, you can afford to use any amount of coal required by the engine without giving the matter much consideration. After we reached Joliet, we took the Alton Limited, and I noticed the same thing on the passenger engine; she fired perfectly, satisfactorily and easily; the engineer, with his head out of the window all the time, never bothering about anything, his ex-injector steadily working, and the run was satisfactory in every respect. The coal was going in very regularly. When we got to Chicago I examined the fire, and I never saw a better. I asked the engineer how much further he could have gone with that fire. He said he could have turned back and gone to St. Louis without touching the fire.

H. T. Bentley (C. & N. W.).—As I understand it, the Strouse stoker is a hand-fired arrangement, and has no conveyor to carry the coal to the hopper. We experimented with one of these stokers in the early days, but probably great improvements have been made in that time. Our men told us at the time we experimented with the stoker that they would rather fire by hand than handle the coal from the tender into the hopper. That was twelve or eighteen months ago, and perhaps changes have been made in the stoker which would overcome the complaint of the firemen. Another objection we had to that stoker was the noise it made in operation. Our men said that with the stoker on the engine, if a torpedo went off and they did not hear it we should not hold them responsible. We took that matter up with the manufacturers, and it is possible they have overcome the two defects mentioned.

Mr. Gossett.—In applying the stokers to our locomotives I figured on raising the deck about 10 inches, that is, the shovel sheet, which will make it easier for the fireman to elevate the coal into the hopper. As it is now, it is rather laborious for the fireman to reach down to the level plane where he is standing, which is necessary to get the proper swing for shoveling by hand firing, but by elevating the deck 10 inches the fireman can stand at his post with a straight back, and that is not so laborious. The present machine runs as silently as a sewing machine.

Mr. Maher.—In the case of the first stoker we put on, we took it off the engine at the end of 4 or 5 miles—it did not work satisfactorily. We connected it up to a temporary firebox and worked on it for almost a week and got it operating all right. We then put it back on a locomotive, and it has been in constant use ever since, about sixty days. We have now twelve engines equipped and two more engines being equipped this week, and five more engines to be equipped next week, which will make a total of twenty engines. We have had some little trouble with the type of packing used on the piston in the end of the stoker where the steam cushions. When that gets to blowing it takes away the cushioning in the cylinder, and we have had one or two failures on the road, but we are putting a tandem metal packing in the piston now, which we are satisfied will overcome that difficulty. One other feature is the condensation from the steam pipe will have to be taken care of and kept out of the cylinder. We are overcoming that by having a valve to let the water out.

We ran a consolidation engine, 22-inch by 30-inch cylinder, from Brighton Park to East St. Louis, a distance of 276 miles, without cleaning the fire. There was practically no stop, the train going through in twelve hours and twenty-five minutes. On the arrival of the train at the terminus the road foreman and the round-house foreman advised that the fire was in good condition, and the engine could have gone over another division without attention to the fire. We have had one engine in particular working between Chicago and Brighton Park, on heavy tonnage trains, where we handled 3,500 tons, and we have made that distance of 122 miles from Bloomington to Brighton Park in from seven hours and fifteen minutes' running time to nine hours, as conditions may warrant.

We have also used the stoker on a Pacific type passenger engine, 23-inch by 28-inch cylinder, and have handled as high as fourteen cars without any difficulty, maintaining 200 pounds easily with the stoker. If no unfavorable developments occur it is the intention to equip all our heavy locomotives with them.

F. H. Clark (C., B. & Q.).—It has been hoped by many of us who have been watching the development of stokers that when we finally found a satisfactory stoker, one that would keep the coal fed properly, and possibly make a saving, we would also have the advantage of smokeless firing. I should be glad to know what kind of a record the Strouse stoker is making as to smoke.

Mr. Maher.—I do not think you are going to get smokeless firing with a stoker to the extent we hoped, for the reason that it is so different from hand-firing that there will be more continuous production of smoke in the fire-box than where the firemen puts in a load and lets it burn out at intervals. The stoker sprays the coal into the fire-box all over the grate surface, and much of that commences to burn before it reaches the surface of the fire. For that reason I do not think we will get away from smoke.

W. McIntosh (Central of New Jersey).—Can brick arches be used in connection with mechanical stokers?

Mr. Maher.—We do not use the brick arch. It would depend on the height of the arch from the grate surface.

The President.—With the Strouse stoker is the firing dependent upon perfectly uniform distribution all the time?

Mr. Maher.—It is a uniform distribution.

The President.—You cannot vary this spray?

Mr. Maher.—You do not need to. It distributes the coal over the surface evenly.

The President.—But suppose you want to direct a little extra coal to one place, can you do that with the stoker in the back corner, for instance?

Mr. Maher.—It will put it in the back corner of a 66-inch box, and put it in the corner of a 75-inch box in a test. The amount is controlled by the fireman's adjustment of the lever of the stoker.

J. F. Walsh (C. & O.).—The stoker can be used in connection with a brick arch. We are experimenting with the Strouse stoker at this moment, but have not gone far enough yet. It is working with a brick arch.

Mr. Curtin (Louisville & Nashville).—I would like to ask what percentage of ash the coal on the Alton contains. I should judge that the stoker is burning some very good coal. How does it work when the fire-box begins to fill with ashes and other impurities?

Mr. Maher.—We haven't experienced any trouble with the coal we are using through having the fire-box fill up. Of course, local conditions will enter into the efficiency and practicability of the stoker in different parts of the country.

D. R. MacBain (N. Y. C.).—Two weeks ago I made a trip of 122 miles on a consolidation engine on the Alton. The engine was 22 inches by 30 inches, and had 33 square feet of grate surface. We had 3,305 tons, sixty-three cars, made the run, deducting delays, from Bloomington to Brighton Park, 122 miles, in six hours and seventeen minutes. In starting out we smoked, and at the first stop I observed that the fire was very light, only 2 or 3 inches in some parts of the box. Then the fire was built up to 6 inches all over, and from that station on the engine seemed to work perfectly. It was absolutely within the control of the fireman to place the coal where he wanted it. The last 40 miles, from Joliet to Chicago, was at a speed of 22 miles an hour, and when we got to Chicago I again looked at the fire, which had not been touched from the start, and there was very little ashes in the pan and the fire was clean and ready to start back with. Considering we had burned about 20 tons of coal in that section of the country, and had an abundance of steam all the way, I consider it a very good record.

Mr. Crawford.—The whole stoker situation, as I see it, resolves itself now into a fairly successful over-feed stoker, and experimentation with two designs of under-feed stoker. One of the under-feed stokers is on the Burlington and the other is being tried under my direction. It has been in service on one of our freight engines, in the hands of a regular crew, for a little over two months, and made in that time about 6,400 miles.

The stoker has what I call a 75 percent job. We have got to fire about 25 percent of the coal by hand. On a through train the amount of hand firing is reduced; on a slow freight, put on sidings from time to time, the fire must be built up by hand. The only point we have actually determined regarding the stoker has been the smoke proposition. We find with readings in Ringlemann's charts that a hand-fired engine, with proper tonnage for its class, fired as carefully as we can, makes an average smoke reading of 2.7. The stoker-engine, on a run where 18 percent was supplied by hand, made a smoke record of 0.9.

It is the intention to put an engine equipped with this stoker on the testing plant at Altoona, and also some other stokers as opportunity offers. We, therefore, hope to be able to give the committee and the association next year more data as to the working of these stokers.

JIG FOR DRILLING GRATE ARMS.

BY C. E. LESTER.

The use of jigs for producing work at a minimum cost, and to insure accuracy and to make parts interchangeable, has become an important factor in railroad work. The accompanying sketches and details for drilling grate lugs were de-

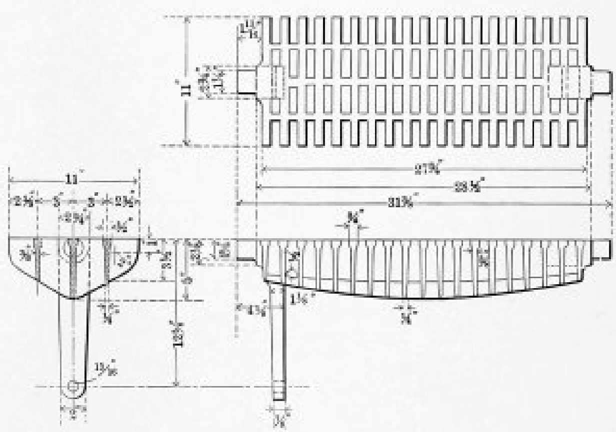


FIG. 1.—GRATE SHOWING DIMENSIONS OF ARM.

signed by the writer to overcome some costly and objectionable features connected with this work. Before this jig was put into use it had been the practice of the men applying grates to locomotives to drill the hole in the grate arm for the connection rods any place they saw fit; this was done notwithstanding the fact that we have blue prints covering this work. The consequent result was that a part set of grates from one

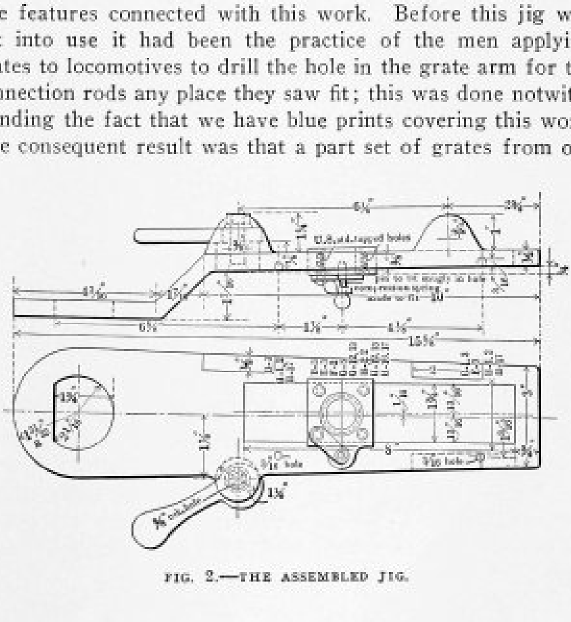


FIG. 2.—THE ASSEMBLED JIG.

locomotive could not be changed to any other locomotive. This feature applied specially to a locomotive at an outside point that required a grate of a certain pattern number. The man in charge would wire into the division shop for a grate without giving the location or size of hole for the connection rod, and the shop force would be practically "up a tree" as to where to drill the arm.

The drill-press hand now has a chart showing the number of grates for different classes of locomotives and the number of grates to be drilled the required lengths. The grates, pattern No. 1,295, are furnished with an arm long enough to accommodate all the different classes of locomotives for which they are required. The grate men now simply take the required number of grates from the casting platform and deliver to the drill-press hand, who, by referring to his chart, sees that, for example, engine 1,022, class H-1, requires three short, four medium and three long-arm grates, and drills them accordingly.

It will be noted that the contour and design of the jig are such that it slips over the trunnion of the grate and lugs on the top of the jig slip over both sides of the grate arm, and the

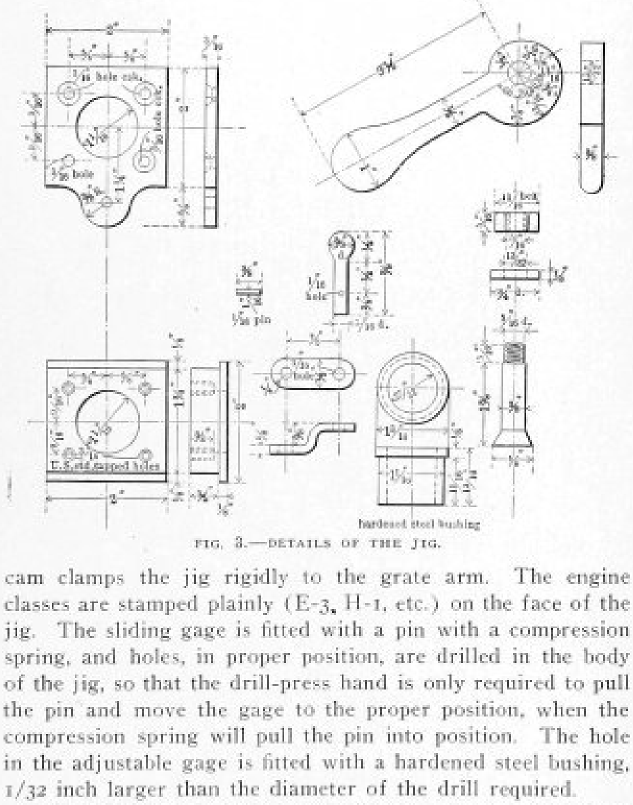


FIG. 3.—DETAILS OF THE JIG.

cam clamps the jig rigidly to the grate arm. The engine classes are stamped plainly (E-3, H-1, etc.) on the face of the jig. The sliding gage is fitted with a pin with a compression spring, and holes, in proper position, are drilled in the body of the jig, so that the drill-press hand is only required to pull the pin and move the gage to the proper position, when the compression spring will pull the pin into position. The hole in the adjustable gage is fitted with a hardened steel bushing, 1/32 inch larger than the diameter of the drill required.

It is found that the use of this device reduces the cost of preparing grates for application as well as creating a movement to the end that, eventually, parts that should be interchangeable will be so. The original device was made from boiler plate and forgings, but patterns are now being made for the construction of all parts possible from malleable iron, so that all shops on the system may be equipped at a minimum cost.

It is dangerous to attempt to open steam boilers for cleaning or inspection purposes until it is absolutely certain that there is no steam pressure within. A pressure of even 1 or 2 pounds per square inch, acting on the large area of a manhole cover, is sufficient to seriously injure anyone attempting to remove it. Do not depend on the reading of the steam gage; lift the safety valve or open one of the taps to make sure that there is no pressure within.

PATCHING A TUBULAR BOILER HEAD.

BY JAMES CROMBIE.

This boiler was 72 inches diameter, 15 feet long, and had 107 tubes 3½ inches external diameter. On examination it was found that the back head was cracked near the bottom, the flange being cracked through the rivet holes in the flange and around the fillet of the head and about 1½ inches on the flat surface of the head.

The plate at the hand-hole was badly corroded, and the bridge between the hand-hole and tube-hole at one side was only 1/16 inch thick. At the opposite side of the hand-hole there was a slight crack in the bridge between the hand-hole and the tube-hole and the plate was thin. (See drawing.) Also a number of the tubes were in bad shape and required renewal. The boiler should have had a new head put in to make a first-class job, but as this was a busy time for the factory it was decided to cut out the bad piece and fit on a patch, the patch to be 25 inches by 15 inches and ⅜ inch thick.

The two bottom rows of tube-holes marked *P* in the drawing were filled with pockets, or blind tubes, 12 inches long. Several of these pockets had to be taken out of the front head to allow the tubes to drop down into the bottom of the boiler and be taken out at the front hand-hole. Ten pockets at the back end in way of repairs had to be taken out. These pockets were taken to the shop and the ragged end cut off at the saw, and were replaced later, after the patch was riveted on. Twenty-four tubes were taken out and renewed. These new tubes were on the premises, but were 16 feet long. The company whose boiler was being repaired would not send these tubes to the shop to be cut, so that they had to be cut with a pipe cutter to the correct length.

Two boiler makers were started on the job to cut out the twenty-four tubes and the pockets, also to cut out the damaged plate. They required about fifteen hours each to do this part of the work, time being lost clearing away dirt and soot. The tubes were heavily scaled, and it took extra time to get them out, as the scale was very hard. The tubes were cut out with a cape-chisel, a slot being cut on one side of the tube and then the tube was knocked in, the same being done at the opposite end.

The rivets were cut off with a side set and then driven out with a backing-out punch; sixteen rivets, ¾ inch diameter, were cut out of the flange, and two rivets, 1 inch diameter, out of the head. The holes were then laid out for the new piece, and drilled with a ratchet drill and drill post, this operation taking the two boiler makers about two hours. One man then started to clean the tube-holes for the new tubes, also dressing up the edges of plate where the piece was cut out, and also cutting and replacing the tubes. The other boiler maker went to the shop to get the necessary rivets and holding-on hammer with a short handle and two riveting hammers.

During this time the new piece had been laid out to the size required, then sheared, and the two corners thinned out, and then the flange was hammered down over a cast iron block, this operation occupying the squad one and one-half hours. The patch was then taken to the job and driven into place, with the aid of a shore against the back wall to force it in, as the new piece had to go between the old flange and the shell plate. After getting the new piece into place the rivet holes and the tube holes were marked; the patch was then taken to the shop and punched, the rivet holes countersunk slightly, and the patch chipped to clear the tube holes, this taking a boiler maker two hours. The patch was then taken back to the job, and the corners heated in a small forge and then placed in position, bolted up and hammered close. The other corner was then heated and hammered up close. It was thought the better plan to make a good, tight job of the fitting and not trust to the rivets drawing up slack corners or slovenly work.

The patch was then riveted up. This occupied the squad six hours, the squad consisting of the two boiler makers and two helpers, supplied by the company for whom the work was being done. One helper was put inside the boiler to hold on the rivets, the other helper, as heater boy, burned the rivets, and was quickly told to clear out, the boiler maker heating the rivets and then getting inside the cleaning door in the wall and hammering down the rivets along with his mate.

The patch was then calked and the new tubes put in and expanded, and then the boiler was filled up ready for the fire. This occupied each boiler maker nine hours. After steam was up everything was found satisfactory.

If this patch had been placed on the outside the flames would have caught the edge of the flange. Then the patch might have more easily been fitted inside the head by thinning down the flange at the joint; but there would have been trouble this way also, as the flames would have caught on the edges of the plate where the piece was cut out; therefore, the only correct method was to slip the new piece between the boiler head and shell plate.

The tube holes and hand-hole were left out of the patch by order of the owner.

The time on this repair was as follows:

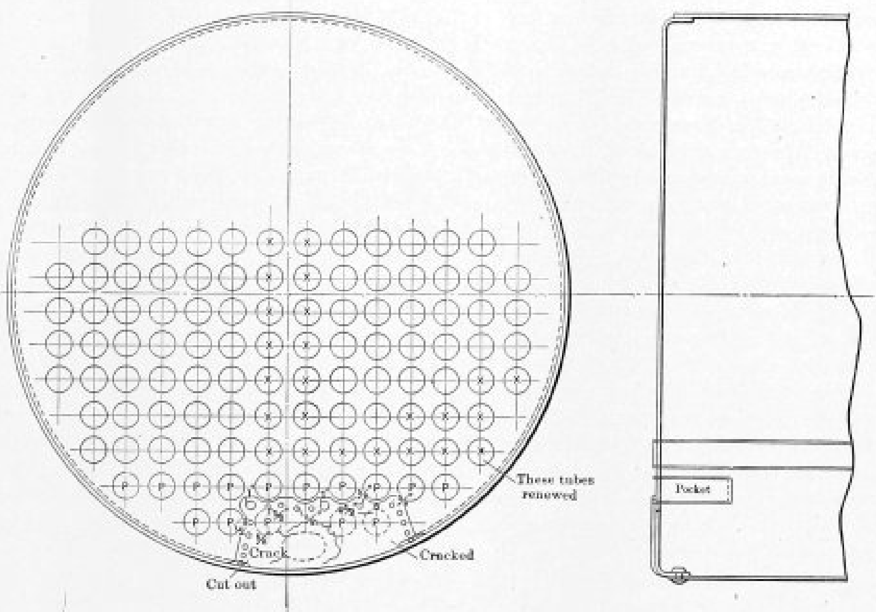
	Hours.
Cutting out, two boiler makers, 15 hours each	30
Drilling, two boiler makers, 2 hours each	4
Flange patch, one boiler maker, 1½ hours each	1½
Flange patch, two helpers, 1½ hours each	3
Punch, chip, etc., one boiler maker, 2 hours	2
Fitting, cutting tubes, etc., two boiler makers, 15 hours each	30
Rivet patch, two boiler makers, 6 hours each	12
Rivet patch, one helper, 6 hours	6
Replacing pockets and filling boiler and testing, two boiler makers, 9 hours each	18
Total	106½

Total time for boiler maker 97½ hours.
Total time for helper, 9 hours.

Material:

16 rivets, ¾ inch diameter; 4 rivets, ½ inch diameter; 2 rivets, 1 inch diameter; 12 rivets, ⅝ inch diameter = 12 pounds, at 5 cents per pound	$0.60
1 plate, 25 x 15 x ⅜ inches, = 40 pounds, at 4 cents per pound.	1.60
	$2.20

Twenty-four tubes, each 3½ inches diameter by 16 feet long, were also required, but these were provided by the company requiring the repairs. The rate for the boiler makers and helper is not given, as this changes with local conditions, boiler makers being paid from 23 to 45 cents per hour in different parts of the country.



LOCATION OF THE PATCH.

TOPICAL DISCUSSION AT THE MASTER MECHANICS' CONVENTION.*

Is the Additional Cost of Flexible Stay-bolts Justifiable?

H. D. Brown (Erie).—I wrote to a number of our members asking their experience in the matter under consideration. I presented six questions to them. For my own part I very much favor the use of flexible stay-bolts, and to my great surprise all the answers to my letters were in the affirmative too. Four of the replies suggested that there should be a committee appointed to work up modern methods for the application of flexible stay-bolts. It seems there has not been any method in universal use of proper adjustment of the flexible bolts. It was suggested that that matter should be given careful attention. Another subject suggested was that the committee, if such a committee were appointed, should tram up the boiler with reference to locating the expansion of the fire-box with regard to the outside shell and the throat sheet and back heads. There was a decided request that there should be opportunities afforded of making tests to determine the best method of applying flexible stay-bolts to staying boilers.

H. T. Bentley (C. & N. W.).—It seems to me that it would be necessary to know whether we are breaking an abnormally large number of stay-bolts or not. It would seem that with a very small stay-bolt breakage the use of the flexible bolt is unnecessary. I believe under some certain conditions stay-bolts are breaking very frequently, and probably in those cases a flexible stay-bolt would be necessary, but I would like to ask Mr. Brown if he knows what his breakage of stay-bolts per engine per year amounts to, whether it is with any particular type of engine he is having trouble, and whether a change in the position of the fire-box may not overcome some of the difficulties he may have on account of having an excessive number of stay-bolts broken.

* As reported in the daily edition of the *Railroad Age Gazette*.

Mr. Brown.—In one case only did I get any information as to the number of stay-bolts broken. In that case the statement was made that the number of rigid or solid bolts that were broken was very large, running up into something like 400 a year. That was on the Wooten fire-box. In many cases we find the cost of application of the flexible stay-bolt high. In other cases it runs from about 35 to 50 percent higher than the application of the rigid bolt.

Mr. Bentley.—One of our engines gave us trouble with the stay-bolts and in redesigning the fire-box, so as to get longer stay-bolts in, we reduced the breakage from fifty to sixty per year, in that engine, down to six or seven. With the type of flexible stay-bolt in general use, is it possible to detect whether they are broken or not?

Mr. Brown.—I find the general practice is to put air pressure in the boiler and then make the test. We find it easiest to make the test by removing the cap.

J. F. De Voy (C., M. & St. P.).—I wish to raise the point as to whether any of the members have ever tried a flexible stay-bolt with the idea of preventing cracked side sheets. I have this suggestion to make, which I think is new: On a certain Atlantic type engine we have a boiler which has a very shallow fire-box. About 18 inches from the mud-ring, and about the center between the forward and back part of the side sheet, we found it was an absolute impossibility to retain the side sheet in the boiler more than six months. There would be a crack developed at that point possibly 24 inches long. We increased the width by adding to the side sheet a distance of 4½ inches above the point mentioned to a point about 7 inches below, and the additional length did not appear to help the case at all. I recommended to the superintendent of motive power that we apply flexible stay-bolts to what I term the cracking zone of the side sheets, or, in other words, two or three rows above where the crack occurred and two or three below. I understand, gentlemen, this is entirely at variance with the usual custom of placing stay-bolts. The results are more than any one could expect. I do not know whether any one else has ever tried this, but I would recommend the plan. It has certainly increased the life of these side sheets in this particular type of boiler. In my opinion, if the boiler was designed on different lines we would not have trouble from cracked side sheets.

Is the Usual Front Row of Crown Bolts in a Locomotive Boiler Beneficial or Otherwise?

C. A. Seley (C., R. I. & P.).—The function of an expansion stay-bolt, from its name as well as its construction, is to facilitate the expansion of the flue sheets, as well as performing its usual duties of supporting the sheets which it connects. If the expansion stay does perform its duties as such, then the crown sheet is unsupported from the flue sheet to first non-expanding stay-bolt, and therefore the expansion stay-bolt is useless, because it does not support and may be left out without harm.

If, on the contrary, the expansion stay does not perform its duties as such, then the expansion feature is useless and may be replaced by a solid stay-bolt, giving cheaper and better construction.

Briefly, then, the condition is this: If an expansion stay-bolt does expand, it is no good, on account of not supporting the sheet. If it does not expand it is no good, because it does not work.

L. R. Pomeroy.—I think one of the important features of this discussion is the fact that all of these so-called flexible stay-bolts at the end of the crown sheet are in tension. I think the stay-bolts do not expand, in the sense of elongation, but rotate and allow a movement with reference to the box and outside shell, which allows the box to adjust itself to the different conditions going on in the side sheet and steam space.

Mr. Fowler.—I want to call attention to some experiments made in the past and reported to this association a great many years ago, I think by Mr. Eddy, who was connected with the Fitchburg Railway. He put a gage on top of the crown sheet at the front end near the top sheet, and set it back at intervals, and immediately noticed the movement of the sheet when he was getting up steam. He found that before there was any steam generation in the boiler whatever, the front of the fire-box expanded, the front sheet expanded the crown sheet, and actually lifted the crown sheet and placed it near the roof sheet, so that the gage rose through the stuffing-box, and showed there was a perceptible decrease between the two sheets. As the steam pressure was generated and applied to the top of the boiler the gage dropped back to its natural position again, and showed that the stays at the front end of the boiler were in tension. If they are slack at the front end, it allows for the rise of the sheet when the boiler is being heated, and they then go back in tension, and do their work when steam is placed on the boiler.

Mr. De Voy.—I wish to correct the statement in one regard and pay a tribute to a man of the old school who was conversant with every detail of the locomotive boiler. I refer to J. M. Boom, who was chairman of your boiler committee and conducted tests for three months during the time that I was the office boy at Frankfort, N. Y., on the old West Shore road about eighteen years ago, so that if you will give credit to Mr. Boom, who presented to this convention a minority report, in which he stated that the flexible sling stay at the front end of a boiler never did any good (and I never knew it to do any good), I think we will be only giving Mr. Boom just credit. I spent two and one-half months on the proposition. When you first put fire in the fire-box there is an expansion all around. We use the gages you referred to. Our experiments were very elaborate. When you first put fire in the fire-box there is an expansion of about 1/100 part of an inch on the whole thing, inside and all. We had gages on the fire-box outside crown sheet, and everything of that kind, and so while I have always been forced—wanted to be in style—to put three rows of sling stays in the front end of the boiler at the crown sheet, I want to tell you there is no more necessity for it than there is of wearing two hats. I want to take this opportunity to pay a tribute to Mr. Boom.

D. J. Redding (P. & L. E.).—These things we have just heard are facts. When you have a lot of rigid bolts in the front ends of your crown sheet, after the fire-box has been in a year or two, you will find the crown sheet bottled down ¼ inch, and the front end of the top sheet be up in the same way. I know, from personal observation, of the introduction of sling stays which do not corrode, which overcome that trouble.

C. E. Fuller.—There is more trouble caused by the boiler maker than in any other way. Keep the boiler maker out of the fire-box. If you allow the boiler makers to work on your flue sheets, using different kinds of rollers and expanders, in that you will find the cause of the trouble with the flue sheets. If you see a flue sheet going up, and a crown sheet going up with it, it has been expanded and stretched by the constant rolling of the flues.

Mr. De Voy.—If you expand the flue sheet do you expand the side sheet? Do they stretch and go up at the same time? I would suggest putting your stay-bolts 4 inches back of the row of rivets in the flue sheet, and find out whether they expand. I think Mr. Fuller explained the whole thing.

Brick Arches and Watertubes in Locomotive Fire-boxes.

J. F. Walsh (C. & O.).—Not considering for the moment the many desirable features in the use of the brick arch in locomotive fire-boxes, we will consider only watertubes, which are applied primarily for the purpose of carrying the arch bricks.

In the four 3-inch watertubes which are used in the fire-boxes of our locomotives we have a total heating surface of about 26 square feet, which aids materially the steaming qualities of the engine, if considered alone.

Again, in the wide fire-box locomotives, with a grate surface of practically 50 square feet, the rapid deterioration of side sheets has been the cause of complaint, due to the buckling and cracking of those sheets at a point close to the flue sheet and crown sheet.

With a total of 250 of that type of engine in service, some of them in service for the past six years, we have had little cause for complaint concerning defects in our side sheets as noted above. This we believe is due to the fact that our arch tubes assist very materially in the circulation of the water, and by that means avoid the overheating of the side sheets.

Therefore, I believe that the arch tube itself, independent of any other feature connected with it, is a desirable addition. We provide ample means for keeping the tubes clean by placing hand-hold plates in the boiler head and in the throat sheet in front of the watertube openings. These are taken off each time the boiler is washed, and the tubes are thoroughly cleaned.

As to the usefulness of the brick arches, in a test recently made on one of our divisions we proved that by the use of the brick arch we can save 20 pounds of coal per mile as compared with the operation of the engines without the brick arch.

Where the brick arch is used the locomotives steam much more freely than without the brick arch, and we are enabled to keep up full boiler pressure regularly.

The use of the brick arch enables the fireman to maintain the maximum boiler pressure regularly. Without the brick arch this cannot be done when the engines are worked to full capacity. Therefore, without the brick arch we cannot haul full tonnage; so by the use of the brick arch we increase the earning capacity of the locomotives and of the railway.

Our brick arches cost us on an average 30 cents per brick. Using ten bricks in each engine means a total cost per engine for arch brick of about $3.

A saving of 20 pounds of coal per mile will mean a saving of 2,000 pounds of coal per 100 miles, and with coal costing us approximately $1.50 per ton we can save the price of the brick arch in a round trip by the saving in coal, and not considering the increased efficiency of the engine.

It would seem quite superfluous to add that by the use of the brick arch we obtain very much better combustion of smoke gases and reduce the quantity of smoke emitted. The same is quite true of the quality of sparks emitted, as the brick arch serves as a baffle to the escape of the cinders, retaining them in the fire-box until consumed. This results in better fire-box efficiency, reducing also the danger from fires along the right of way.

Our transportation officials and our enginemen and firemen complain if our supply of arch brick becomes exhausted, or if for other reasons we have to operate our engines without arch brick.

Dependent on the quality of the brick and the frequency that it has to be removed for flue or other repairs, a set of brick in our heavy locomotives will last from two to six weeks. Where the quality of the brick is good it may be removed to permit of work being done and used again several times.

Prof. H. Wade Hibbard (University of Missouri).—In connection with fire-brick arches in locomotives, some information that I gained last summer when I was connected with a railway making very extensive use of fire-brick arches may be of value to this association, and that is with regard to the durability of the fire-brick. I believe that sufficient attention has not been paid to the sort of fire-brick which should be used for this purpose. Fire-brick for locomotives should have a greater degree of toughness and less ability to stand high temperature. The temperature in a locomotive fire-box is low as compared with the temperature in an open-hearth steel furnace for the manufacture of open-hearth steel, and if you desire to have fire-brick which will stand mechanical abuse in a locomotive fire-box, then you should get the tough fire-brick rather than the high-temperature fire-brick.

George L. Fowler (*Railroad Age Gazette*).—I think it would be interesting if some members of the association would give data as to what results they are getting where they have poor water and bad coal. Mr. Walsh's road, as I understand it, is remarkably blessed in two particulars: they have wonderfully pure water and a superb quality of coal. Now, it is quite possible that entirely different results might be obtained where you have a bad scaling water in use. It would be very interesting to have some data in that particular.

The President.—Our experience has been like most roads, I think, that it is largely a question of local conditions. We use brick arches in some districts, and we find their use inadvisable in others. There is very little doubt about the saving of coal, but the question is whether the trouble makes it a paying proposition. I think the Lake Shore has been doing a great deal of work on brick arches lately, have you not, Mr. Parish?

Le Grand Parish (Lake Shore).—We have practically all the engines on the Lake Shore equipped with brick arches, including switch engines. About two years ago, in looking into the subject, we found that we had perhaps 100 engines maintaining the fire-brick, and we had to fight every minute to maintain that in the 100 engines, on account of the difficulty we had in the engine houses. There was also one other difficulty which we overcame. The great trouble in maintaining the arch brick in locomotives has been on account of the fact that we all used a brick that was too long. They were broken in shipping, they were broken in handling in the engine house, and they were broken when they were removed, and all that sort of thing. We got entirely out of fire-brick. I was having all kinds of trouble on account of the engines not steaming. We use a lot of old brick that we had on hand which we considered obsolete, and the men who had this work in charge, our supervisor of boilers and supervisor of locomotive machinery, were told for heaven's sake to use that brick in some way so that they would have brick arches in the engines. The result was they designed a short brick which rested in between the arch tubes, and it more than doubled the life of our brick, and got us practically out of all our troubles. The result of that experiment has been that we have equipped everything on the Lake Shore with arch brick, and the saving in cost of coal is something enormous. I cannot give you the figures; I am sorry I haven't got them. It has made a wonderful difference in our coal—that in connection with perhaps seventy-five other things, a number of which were mentioned in a previous paper.

A. E. Manchester (C., M. & St. P.).—It has been the practice of the C., M. & St. P. for twenty years to use arch brick. We are thoroughly and firmly convinced of the good of the arch brick, and our men are in the same position, and feel that they could hardly run the engines without it. Whenever a condition arises that on account of the shortage of stock, or something of the kind, the arch bricks are not maintained, reports are always coming in that the engines are not steaming, etc., and that is given as the cause. We believe that a great deal of good is done with the brick, and we get just as good results, if not better, in the bad-water districts as we do in the good-water districts.

HOW TO PREVENT BREAKAGE OF WATER-GAGE GLASSES.

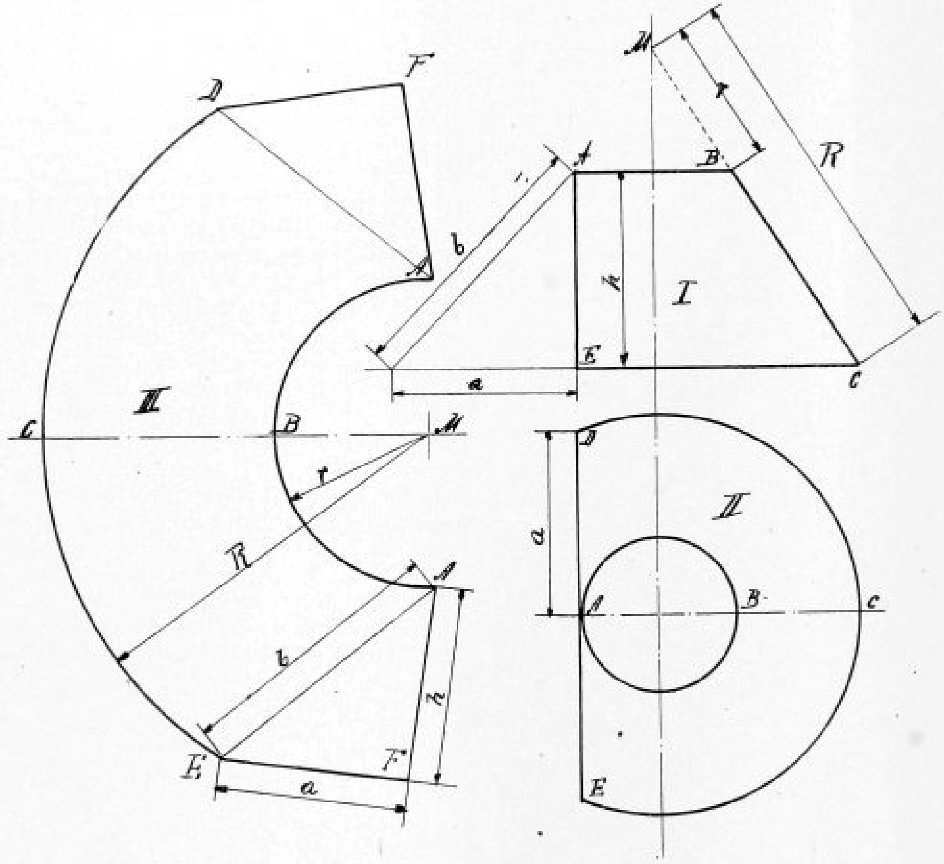
Water-gage glasses are commonly made of a special grade of glass carefully annealed. The manufacturers usually claim that they are capable of withstanding a hydraulic pressure of several thousand pounds per square inch, and also that one end of the glass can be suddenly heated to a red heat without causing a fracture. If the tubes are capable of withstanding such high internal pressures and undue local expansion, and undoubtedly these claims are jutifiable to a certain extent, it is a puzzle to many boiler users why so many gage glasses break when applied to a boiler carrying only 200 pounds pressure.

The cause is usually to be found in the manner of installing and packing the glasses. If the glass is not free to expand when suddenly subjected to high temperatures and high pressures, it will invariably break.

One of the most prolific causes of breakage is the use of too large a glass for the size of the gland. The first requirement is, therefore, a gland of ample size, so that it will not interfere with the natural expansion of the glass when subjected to steam pressure. The next requirement is that the gage cocks be set perfectly true, otherwise the glass will have too little space for expansion on one side. Furthermore, the packing must be suitable and of the very best quality. Rubber washers, even of the very best quality, are not of themselves sufficient. With steam of 200 pounds pressure or more they soon become softened to a pulp and blow out. To prevent this they should have a ply of asbestos twine or cord on each side of them, which protects them effectively.

The next point to be noted is the screwing up of the glands. You should be able to move the glass with your finger and thumb after it is in place. If you cannot do so there is not sufficient room for expansion, and breakage will result. With the glass left an easy fit there will be a slight leakage of steam after the pressure is turned on, but the glass and packing will soon take up and this will stop. Even then, to ensure perfect safety, the nut should be slackened again almost to the leaking point.

If the foregoing points are borne in mind, and, in addition, none but the best gage glasses are used and a fair amount of judgment is used in admitting steam gradually after the glass is put in place, most of the troubles and annoyances due to the breakage of gage glasses will be overcome.



SIMPLE METHOD OF LAYING OUT A TAPER COURSE WITH A FLAT SIDE.

Layout of a Taper Course with a Flat Side.

In the February, 1908, issue of The Boiler Maker, H. S. Jeffery describes the layout of a taper course with a flat side. It is not necessary to lay out this piece by triangulation. There is another simpler method. Figs. 1 and 2 give all the data necessary for laying out the article. Fig. 3 is the layout itself. Using *M* as a center and *R* and *r* as radii, draw arcs, the length of the arc *A-B-A* in Fig. 3 being the same as the arc *A-B-A* in Fig. 2. By using *A* and *A* as centers in Fig. 3, draw arcs with the radius *b*, cutting the outer arc at *E* and *D*. Again using *A* and *A* as centers, draw arcs with the radius *h*. Then using *D* and *E* as centers, with the radius *a* draw arcs intersecting those previously drawn at *F* and *F*. Connect *F* with *A* and *E*, and also with *A* and *D*, and you have the complete outline of the pattern. John Jashky.

That superheaters are now being considered a necessary adjunct to marine boilers in a great many cases is shown by the fact that in the United States no less than twenty vessels, aggregating 158,450 horsepower, are so equipped, eight of which are naval vessels.

STEAM BOILER INSPECTION LEGISLATION IN ENGLAND.

In order to show how extensive and thorough are the requirements for steam boiler inspection in Great Britain we give below a résumé of the principal legislation now in force in that country pertaining to steam boilers. In this connection we wish to remind our readers that in the United States there is not in force a single Federal act governing the inspection and operation of stationary boilers; that only five States have such laws, not all of these being adequate or affording proper protection to steam users; also, that even in the majority of our large cities there are not proper statutes pertaining to steam boilers. As a consequence of this criminal lack of proper protection nearly 300 people have been killed and over 500 others injured each year for the last ten years due to explosions of stationary boilers alone. During the same period the average number of persons killed and injured each year due to the explosion of locomotive boilers belonging to railway companies, which are the most carefully inspected boilers in this country, was only 5.5 and 9.6, respectively. This shows how great is the necessity for the immediate enactment of adequate laws governing the inspection and operation of stationary steam boilers in the United States. That such laws would insure proper protection may be inferred from the fact that in England, where the following laws are in force, the average number of persons killed each year by boiler explosions is only about thirty.

At the present time the principal legislation in reference to steam boilers in Great Britain is as follows:

The Boiler Explosions Acts, 1882 and 1890; referring to official investigations into boiler explosions.

Factory and Workshop Act, 1901; referring to the inspection of boilers in factories and workships.

The Metalliferous Mines Regulation Acts, 1872 and 1875; referring to boilers in mines.

The Coal Mines Regulation Act, 1877; referring to boilers in collieries.

The Quarries Act, 1894; referring to boilers in quarries.

BOILER EXPLOSIONS ACTS.

These acts provide for an official inquiry to be made into all cases of explosions of boilers which occur in the United Kingdom, except of boilers used exclusively for domestic purposes, or any boiler used in the service of His Majesty, or any locomotive boiler belonging to a railway company.

The definition of the term "boiler" is a very wide one, and covers all classes of steam boilers, also vessels in which steam is used, and hot-water boilers, also steam pipes, boiling pans, kiers, steam jackets and the like. There is no definition of the term "explosion."

When an explosion occurs, the owner or user of the boiler is required by the act, under penalty, to send notice to the Board of Trade. Following this, the Board of Trade send an engineer to make a preliminary inquiry, or they may, if they think fit, order a formal inquiry to be held. Such formal inquiries are conducted by two commissioners, one of whom is a barrister and one an engineer. The commissioners generally inquire into the cause of the explosion, the up-keep and management of the boiler, and the regular inspection of it. They have power to order payment of costs, which, in effect, are equal to fines. They have regularly insisted on the importance of every boiler being properly inspected and receiving proper attention in its management and maintenance.

FACTORY AND WORKSHOP ACT, 1901.

Below is given copy of Section XI. of this act, referring to the equipment, maintenance and thorough examination of steam boilers used for generating steam in a factory or workshop, or in any place to which any of the provisions of the act apply:

SECTION XI.

1. Every steam boiler used for generating steam in a factory or workshop, or in any place to which any of the provisions of this act apply, must, whether separate or one of a range,
   (*a*) Have attached to it a proper safety valve, and a proper steam gage and water gage, to show the pressure of steam and the height of water in the boiler; and
   (*b*) Be examined thoroughly by a competent person at least once in every fourteen months.
2. Every such boiler, safety valve, steam gage and water gage must be maintained in proper condition.
3. A report of the result of every such examination, in the prescribed form, containing the prescribed particulars, shall within fourteen days be entered into or attached to the general register of the factory or workshop, and the report shall be signed by the person making the examination, and, if that person is an inspector of a boiler inspecting company or association, by the chief engineer of the company or association.
4. A factory or workshop in which there is a contravention of this section shall be deemed not to be kept in conformity with this act.
5. This section shall not apply to the boiler of any locomotive which belongs to and is used by any railway company, or to any boiler belonging to or exclusively used in the service of His Majesty.
6. For the purposes of this section, the whole of a tenement, factory or workshop shall be deemed to be one factory or workshop, and the owner shall be substituted for the occupier, and he shall register the report referred to in this section.

It will be seen that this section renders compulsory the thorough examination of all steam boilers which come within the provisions of the act.

METALLIFEROUS MINES REGULATION ACTS.

These acts and the special rules under the acts provide that every steam boiler shall be provided with a proper steam gage and water gage, and also with a proper safety valve, and shall be properly inspected periodically.

COAL MINES REGULATION ACT.

This act and the special rules under the act provide that each steam boiler, whether separate or one of a range, shall have attached to it a proper safety valve, and also a proper steam gage and pressure gage, and shall be properly inspected periodically.

QUARRIES ACT.

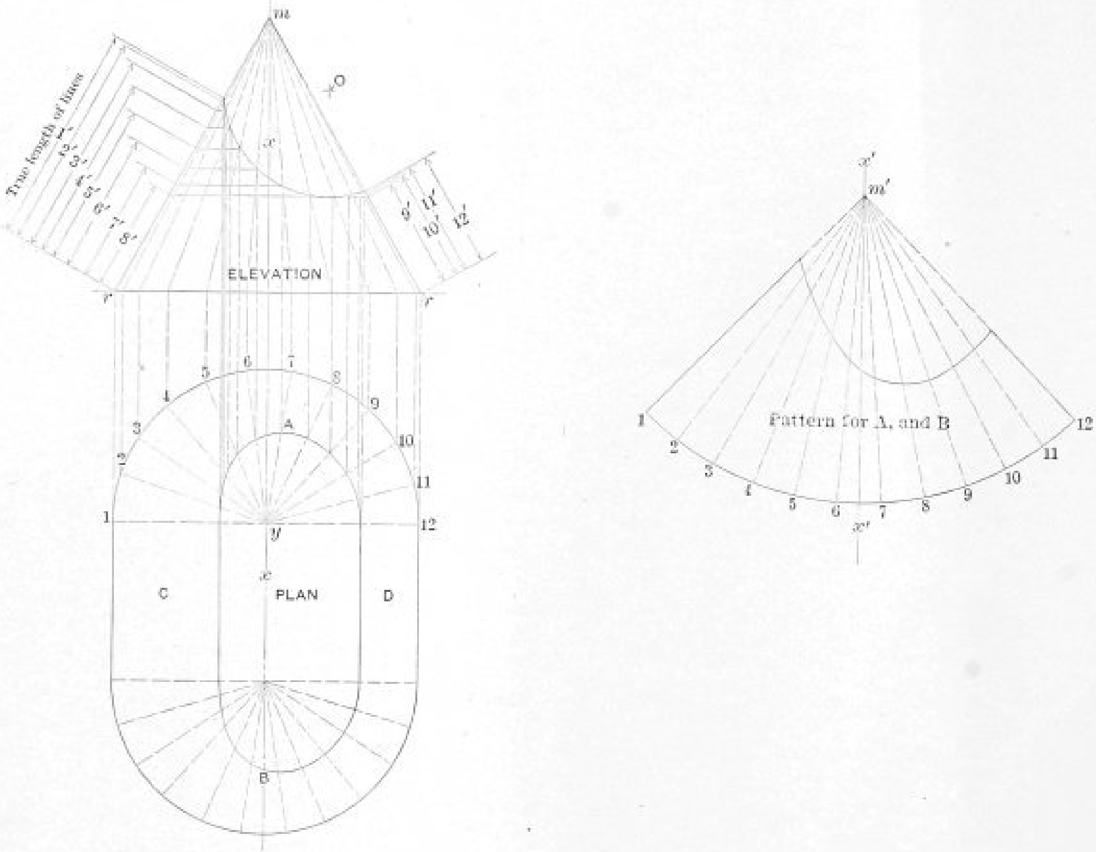
The quarries act provides for special rules in reference to the inspection of steam boilers. Rules have been drawn up for the different districts, generally following similar lines. These rules require regular inspection of each steam boiler by a competent engineer.

In the fleet of American battleships that encircled the globe there were the following types of boilers: Double-ended Scotch boilers (working pressure 180 pounds) in the *Kearsarge* and *Kentucky*, single-ended Scotch (working pressure 180 pounds) in the *Wisconsin*, *Alabama* and *Illinois*, Thornycroft boilers (working pressure 230 pounds) in the *Missouri* and *Ohio*, Niclausse boilers (working pressure 265 pounds) in the *Georgia*, *Virginia* and *Maine*, Babcock & Wilcox boilers (working pressure 265 pounds) in the *Nebraska*, *New Jersey*, *Rhode Island*, *Louisiana*, *Connecticut*, *Vermont* and *Minnesota*.

LAYOUT OF A TRANSITION PIECE.

BY C. B. LINSTROM.

The ilustration shown in connection with this article represents an object which is encountered very frequently in sheet metal work when wishing to make a connection to a pipe having an opening along its longitudinal plane. The development of the pattern for this object is obtained in the usual manner as applied in developments for conical connections. An examination of the drawing shows that the object consists of one-half the frustum of a cone at each end, as shown at *A* and *B*, plan view, connected together by two rectangular surfaces *C* and *D*.



PLAN, ELEVATION AND PATTERN OF IRREGULAR TRANSITION PIECE.

CONSTRUCTION.

It will be noted that in this development a full plan view is shown. This, however, is not necessary, as in shop practice the only requirements needed in obtaining the necessary data for determining the true length of lines to be used in developing the pattern are the elevation and the semi-circle in the plan view. In this case the full plan view is constructed in order to give a clearer idea as to the nature of the problem and to show how the object appears when viewed from above.

To construct the problem, draw the center line *x-x*, convenient in length, then locate the respective dimensions for the height and base; connect the points *r-r* of the base with the vertex *m*. The center for the connecting cylinder is then located in its required position; in this instance it is shown at *O*. Set the dividers or trammel point equal in length to the radius of the pipe, and using the apex *O* as a center, describe an arc, cutting the outside elements of the cone as shown. It will now be necessary, in order to complete the elevation, to draw the plan view; hence, at a convenient distance from the base of the elevation locate the point *y* on the center line *x-x*; set the dividers equal in length to one-half the base of the elevation, and using the point *y* as a center draw a semi-circle; divide the semi-circle into any number of equal spaces, in this case eleven, numbered from one to twelve, inclusive. At right angles to the base of the elevation extend these respective points of division up until they intersect the base; connect these points with the vertex *m* by radial construction lines, thus creating what is termed the elements of the cone. These intermediate lines are all shown foreshortened, with the exception of the outer boundary lines, which are shown in their true length. Where these intermediate lines intersect with the connecting plane of the cylinder determines the points from which the required or true length of lines to be used in the development of the pattern are obtained. This is accomplished by projecting these points of intersection over at right angles to the center line *X-X* until they intersect the outer elements of the cone, as shown at 1', 2', 3', 4', 5', etc., and designated on the drawing as "true length of lines."

If it is desired to develop the full plan view it can be very readily done in this manner, viz.: Connect the points 1, 2, 3, 4, 5, etc., in the plan to the apex *y;* hence these lines represent the corresponding radial lines of the end elevation, and appear in this manner when viewing the object from above. The elliptical or irregular curved portion is also a foreshortened view of the cutting plane of the connecting cylinder. By projecting the points of intersection between the elements of the cone and the cutting plane of the cylinder down to the corresponding lines in the plan view, at the intersection of these points, the ellipse is determined. The rectangular surfaces *C* and *D* are then drawn. The irregular-shaped portion *B* is drawn in the same manner as explained for the development of *A*.

DEVELOPMENT OF THE PATTERN.

Draw the center line x'-x' of an indefinite length, then locate the points m'; set the trammel points equal in length to the distance m to r of the elevation, and using m' in the pattern as a center, draw an arc equal in length to the distance around the semi-circle in the plan view, as shown, from one to twelve, inclusive. This distance can also be found by calculation: Multiply the distance r-r, or the diameter of the base, by the constant 3.1416, and divide by two; this will give the required stretchout of one-half of the base. Space the stretchout into the same number of equal spaces as the plan view; connect the center m' and these respective points with radial construction lines. The camber line for the top connection is obtained by transferring the true length of lines shown in the elevation to the corresponding lines in the patterns. Add for laps, and the patterns for *A* and *B* are complete.

The patterns for *C* and *D* are not shown, as their development only requires straight-line drawing; hence, further comment is not necesary, other than that the heights for the respective patterns are different. The height for *C* is equal to the distance 1, and for *D* it is equal to the distance 12, which are the two outer boundary lines of the frustum.

A New Floating Skimmer and Surface Blow-off.

To a small boiler shop in the oil region of Pennsylvania, where brains are a larger asset than money, there came one day an order from the recently-acquired traveling salesman for several boilers with floating skimmers. He had evidently inserted this item to bewilder his competitors, and left it "up to the shop" to work out its own salvation.

Upon communicating with the companies that handled this product it was learned that the selling price was about $125 apiece, and as the article was patented it looked as though money would be lost on this order. However, the proposition was turned over to the superintendent, who was also the draftsman, and after considerable pondering he at last devised the scheme shown in the sketch.

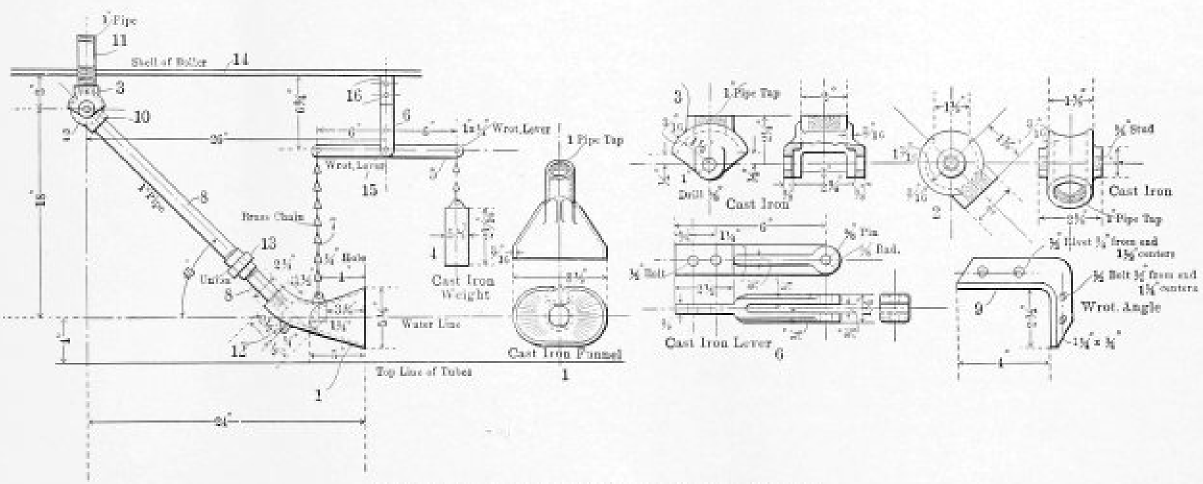
No. 1 is the funnel, which floats, half submerged. Nos. 2, 3 and 10 are parts of the knuckle mechanism, which allows the funnel to follow the changing level of the water. No. 4 is the balancing weight, which is attached by a brass chain, lever and fulcrum bar, 5, 6 and 7, to the funnel. No. 8 is the connection of pipe from the funnel to the knuckle. No. 9 is a bracket fastened to the boiler, to which is attached the fulcrum bar, No. 6. No. 11 is a nipple, screwed through the boiler shell into the knuckle, No. 3, and onto a globe valve connected with the atmosphere or a reservoir. No. 12 is a lug, which was cast on the funnel so that a weight might be hung on to increase the weight of same. This was found unnecessary, and may be dispensed with. No. 13 is a union, to facilitate joining together of the parts, and No. 14 is the shell of the boiler.

The primary principle is the displacement one, and the action is so positive that when testing in an open tank a slight agitation of the fluid caused the lever, No. 5, to move in perfect unison with same.

It is evident that a skimmer of this kind can be used in any type of boiler or tank, and should be of great value to the packing-house business, where they have large rendering tanks, and are called upon to discharge surface impurities and also ascertain the condition of the substance within the tank.

The greatest advantage of this skimmer is its simplicity. There are no copper balls to be worked upon by the acids present or to be opened in time and rendered useless by fluid entering within.

The actual cost, counting patterns and labor, for this job amounted to less than $5 apiece. "PENNSYLVANIA."



DETAILS OF FLOATING SKIMMER AND SURFACE BLOW-OFF.

The Advisablity of Installing a Hot-Water Boiler Washing and Refilling System.*

BY E. A. MURRAY.

The sudden failure of locomotive boilers by cracked fire-box sheets, broken stay-bolts and leaky flues is due to the contraction and expansion of the boiler, and is caused by the rapid change in temperature when the boiler is being washed. This contraction and expansion can be eliminated to a great extent by the installation of a hot-water boiler washing and refilling system.

The boiler-washing system on which the following report is based is of the three-pipe type; that is, a hot-water, a cold-water and a blow-off line. A connection is made from the locomotive boiler to the blow-off line, it being in turn connected to the two heaters, and the blow-off water and steam from the locomotive boiler, together with any additional steam that may be had from power houses and air compressors, is utilized in heating the water for washing and refilling the boiler, there thus being, of course, no expense incurred. The hot water is conveyed from the heaters through the round-house, and a drop made at each alternate stall, and is connected to a mixing box, to which there is also connected a cold-water line, which is used for the purpose of reducing the temperature of the water for washing-out purposes. The water used for this purpose is usually about 110 degrees F.

* Read before the International Railway General Foreman's Association, June, 1909.

After the boiler is washed, it is refilled with hot water at as high a temperature as can be procured from the heaters. A recent test showed the temperature of the hot water delivered to the boiler to fluctuate between 150 and 170 degrees during the day. The temperature of the fire-box was taken at different periods of the washing-out operation, and found to be as follows:

	Degrees.
Before blowing off	158
After blowing off	140
After washing	130
After refilling	138

Which indicates, of course, that the metal in the boiler was being maintained at a comparatively high degree of temperature during the process of washing.

A test also showed that a boiler could be blown off in 40 minutes, washed in 26, refilled in 12, and the steam pressure raised to 100 pounds in 20 minutes, thus making a total of 1 hour and 38 minutes for the whole operation. While using the old method of washing out boilers, we found that it took 3 hours and 38 minutes to obtain the same results, and we have thus been enabled to make a saving of 2 hours' time per engine, reducing the terminal detention of a locomotive, which is one of the admirable features of the hot-water system, as, of course, the earning capacity of a locomotive is realized while in service, and not while standing in the round-house.

We have also found that we make a saving of about 1,000 pounds of fuel per engine, which, of course, represents quite a saving when the number of engines washed per month is taken into consideration.

No trouble is experienced in removing mud, etc., from the boilers with hot water. It has also improved the working conditions in the round-house on account of eliminating the fog-steam and noise, and permitting work being performed on the engine while the boiler is being blown off. It further tends to prolong the life of the metal structure by doing away with the presence of moisture, which, of course, is liable to cause corrosion.

This system, however, does not utilize the blown-off water from the boiler for wash-out purposes, which should be considered in localities where the cost of water is high. However, a saving of 25 percent on the cost of boiler repairs can be made by installing the hot-water system. This percent, however, is an arbitrary figure, as the plant on which the test was made has not been in operation long enough to obtain any definite figure along this line.

A wash-out plant necessary for a thirteen-stall round-house would cost, approximately, $9,000, and the cost of maintenance of the plant is very small, and it is the opinion of the committee that the hot-water boiler washing and refilling system is a good investment, and one on which a good saving can be made.

Horsepower and Commercial Rating of Steam Boilers and Steam Engines.

BY R. E. M'NAMARA.

Strictly speaking, as a steam boiler does not move or perform work in that sense, there is no such thing as the horsepower of a boiler. Therefore, it is always a matter requiring an application of the laws governing the effects of heat, force and work to so proportion the motive power that the load in a steam plant may be carried economically. The term boiler horsepower has come into such general use, however, that a few of the common definitions will be given, together with various tables and data that the writer has gathered for daily use and general approximation. When we consider that the ordinary throttling and slide-valve engine uses 35 to 45 pounds of steam per horsepower per hour, the simple Corliss 24 to 30, the Corliss condensing 19 to 22, and the compound Corliss condensing 14 to 17, it will be seen that the so-called standard boiler horsepower, which consists of the evaporation of 30 pounds of water per hour from a feed-water temperature of 100 degrees F. into steam at 70 pounds gage pressure, may show a high or low value per unit of work, according to the type of engine to which it is applied.

One horsepower, the standard unit of work, is equivalent to the raising of 33,000 pounds vertically 1 foot in one minute, which would be 550-foot pounds per second, 1,980,000-foot pounds per hour, or 42.42 heat units per minute.

In steam engines, dynamometers of the absorption or transmission types are used for the measurement of horsepower, delivered at the shaft.

The formula $\dfrac{p \times l \times a \times n}{33{,}000} = \text{I. H. P.}$, in which

I. H. P. = indicated horsepower.
p = mean effective pressure in pounds per square inch.
l = length of stroke in feet.
a = area of piston in square inches.
n = number of working strokes per minute

is the system used when engine indicator cards are taken for the purpose of finding the indicated power. Thus, engine horsepower being based on work performed, and boiler horsepower being comparative to heat units absorbed, it follows that if both can be reduced to the same standard of comparison the one is mutually convertible into the other.

Foot pounds and British thermal units constitute the medium through which this comparison may be made. A foot-pound is 1 pound of force exerted through 1 foot of space. A British thermal unit is the quantity of heat required to raise the temperature of 1 pound of water 1 degree F.; that is, from 62 degrees to 63 degrees. It has been found that a 1-pound weight falling from a height of 778 feet will elevate the temperature of 1 pound of water 1 degree F., or, what is the same thing, 778 pounds falling 1 foot high; thus, in a British thermal unit there are 778-foot pounds. It has been estimated that the perfect combustion of 1 pound of coal will produce 14,000 British thermal units. As there are 778-foot pounds in a British thermal unit, and 33,000-foot pounds = 1 horsepower, then $778 \times 14{,}000 = 10{,}892{,}000$, and $\dfrac{778 \times 14{,}000}{33{,}000 \times 60} = 5\tfrac{1}{2}$ horsepower in each pound of coal. Owing to various causes and losses, however, not over 1 horsepower per pound of coal has ever been derived.

The American Society of Mechanical Engineers have at various times adopted the following to constitute a boiler-horsepower: (1) The evaporation of 34½ pounds of water from and at 212 degrees. (2) The absorption by the water in the boiler of 33,330 heat units. (3) The evaporation of 30 pounds of water per hour from a feed-water temperature of 100 degrees F. into steam at 70 pounds gage pressure. As all boilers can be forced, however, some to nearly double their rated capacity, any method that does not take into account the fuel consumption in the calculation can be made to give widely different results. Thus, assuming an ordinary 66-inch by 16-foot horizontal tubular boiler: The heating surface will be about 1,400 square feet, the grate area about 25 square feet. If 6 pounds of coal per square foot of grate surface per hour be burned, evaporating water at the rate of 30 pounds per hour from a feed temperature of 100 degrees F. into steam at 70 pounds gage pressure, there will be no difficulty, under favorable conditions, in evaporating 9½ pounds of water per pound of coal. The resultant horsepower will be

$$\frac{25 \times 6 \times 9\frac{1}{2}}{30} = 47\frac{1}{2} \text{ horsepower.}$$

If the rate of combustion be increased to 15 pounds of coal per square foot of grate surface per hour under the same conditions, the horsepower will be $\frac{25 \times 15 \times 9\frac{1}{2}}{30} = 118.7$, this being slightly above the normal rating of horsepower based on *heating* surface for this type of boiler. Further increasing the rate of combustion with forced draft to 25 pounds of coal per square foot of grate surface per hour, which can be done, though not always economically, the water evaporation will fall to about 8 pounds per pound of coal, the equivalent horsepower will be $\frac{25 \times 25 \times 8}{30} = 166\ 2/3$. While a high rate of combustion is essential to economy, the last calculation would, in most cases, if practiced, be going to extremes; one exception, however, being the locomotive, in which the proportion of grate to heating surface is abnormally small. One hundred and fifty pounds of coal per square foot of grate surface per hour has been delivered into the fire-box of a locomotive. A portion of it, however, was drawn through the tubes by the blast and thrown out of the stack unconsumed. The following table gives the ordinary ratio of grate to heating surface in different types of boilers:

Locomotive, 50 and 100 to 1; watertube, 35 and 40 to 1; tubular, 25 and 35 to 1; vertical, 25 and 30 to 1; flue type, 20 and 25 to 1.

As many builders rate a horsepower to a certain number of square feet of heating surface, an approximation for rough usage is as follows:

Watertube, 10 to 12; locomotive, with natural draft, 12 to 16; horizontal tubular, 12 to 14; vertical, 14 to 16; flue boilers, 8 to 12.

Calculations will prove that the standard horsepower rules, based on evaporation and absorption, all amount to the same thing. In determining the horsepower of a boiler, however, while it is performing its daily and normal work, having a gage pressure of, say, 125 pounds, the rule based on the evaporation of 34½ pounds of water from and at 212 degrees cannot at once be conveniently used, for at 125 pounds pressure (referring to steam tables) the evaporation would be *at* a temperature of 344 degrees. If the pressure were 200 pounds, the corresponding temperature of evaporation would be 381 degrees, at 50 pounds 280 degrees, thus showing that an increase of pressure elevates the temperature or boiling point; conversely, if the pressure be lowered, the boiling point is also lowered. If the atmospheric pressure of 14.7 pounds be removed from the surface water will boil at 70 degrees F. and generate steam at .33-pound pressure. (See *Hutton's Steam Boiler Construction.*) It will also boil at freezing point, 32 degrees F., if the pressure be reduced to .089 pound. Using the factor of 30 pounds per hour from a feed temperature of 100 degrees into steam at 70 pounds gage pressure is the most convenient rule applied, this being equivalent to the evaporation of 34½ pounds of water, from and at 212 degrees. To apply the rule to a boiler in use a table of the properties of saturated steam is needed.

Rule: Subtract the number of heat units in a pound of water at the feed temperature from the total number of heat units in a pound of steam at the given pressure, divide the difference by 966. (965.7 being the exact number of British thermal units required to evaporate 1 pound of water at 212 degrees into steam at 212 degrees), and multiply the quotient by the number of pounds of water really evaporated, the answer will be the number of pounds which would have been evaporated from and at 212 degrees. This divided by 34½ will give the horsepower.

For convenience in using, the following table—from *Power*—has been arranged for all ordinary gage pressures and feed temperatures:

GAGE PRESSURES IN POUNDS PER SQUARE INCH.

Feed-Water Temperature in Degrees Fahrenheit.	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
50	29.57	29.29	29.14	29.02	28.92	28.84	28.77	28.70	28.64	28.59	28.54	28.49	28.45	28.41	28.37	28.33	28.29	28.26	28.23	28.20	28.17
60	29.77	29.51	29.40	29.28	29.18	29.09	29.02	28.95	28.89	28.84	28.79	28.74	28.69	28.65	28.61	28.57	28.54	28.51	28.48	28.45	28.42
70	30.04	29.81	29.66	29.54	29.44	29.35	29.27	29.21	29.15	29.09	29.04	28.99	28.94	28.90	28.86	28.82	28.78	28.75	28.72	28.69	28.66
80	30.31	30.08	29.93	29.80	29.70	29.61	29.53	29.46	29.40	29.34	29.27	29.24	29.19	29.15	29.11	29.07	29.03	29.00	28.97	28.90	28.91
90	30.59	30.36	30.20	30.07	29.99	29.88	29.80	29.73	29.67	29.61	29.55	29.50	29.45	29.41	29.37	29.33	29.29	29.25	29.22	29.19	29.16
100	30.89	30.64	30.47	30.34	30.24	30.15	30.07	30.00	29.93	29.87	29.82	29.77	29.72	29.67	29.63	29.59	29.55	29.51	29.48	29.45	29.42
110	31.17	30.93	30.76	30.63	30.52	30.43	30.34	30.27	30.20	30.14	30.09	30.04	29.99	29.94	29.90	29.86	29.82	29.78	29.72	29.71	29.68
120	31.64	31.22	31.05	30.91	30.80	30.71	30.63	30.55	30.48	30.42	30.36	30.31	30.26	30.21	30.17	30.13	30.09	30.05	30.01	29.99	29.95
130	31.76	31.52	31.34	31.20	31.09	30.99	30.91	30.83	30.76	30.70	30.65	30.59	30.54	30.49	30.45	30.41	30.37	30.33	30.29	30.25	30.22
140	32.01	31.82	31.64	31.50	31.38	31.29	31.20	31.12	31.05	30.99	30.93	30.88	30.83	30.78	30.73	30.69	30.65	30.61	30.57	30.53	30.50
150	32.39	32.12	31.94	31.80	31.68	31.58	31.50	31.42	31.35	31.28	31.22	31.17	31.12	31.07	31.02	30.97	30.93	30.89	30.85	30.81	30.78
160	32.71	32.44	32.26	32.11	31.99	31.89	31.80	31.72	31.65	31.58	31.52	31.46	31.41	31.36	31.31	31.27	31.23	31.19	31.15	31.11	31.08
170	33.03	32.76	32.58	32.43	32.31	32.20	32.11	32.03	31.96	31.89	31.83	31.77	31.71	31.66	31.61	31.56	31.52	31.48	31.44	31.40	31.37
180	33.37	33.09	32.90	32.75	32.63	32.52	32.43	32.34	32.27	32.20	32.14	32.08	32.02	31.97	31.92	31.87	31.83	31.79	31.75	31.71	31.67
190	33.71	33.43	33.23	33.08	32.95	32.84	32.75	32.66	32.59	32.52	32.45	32.39	32.33	32.28	32.23	32.18	32.14	32.10	32.06	32.02	31.98
200	34.06	33.77	33.57	33.41	33.28	33.17	33.08	32.99	32.91	32.84	32.77	32.71	32.65	32.60	32.55	32.50	32.45	32.41	32.37	32.33	32.29
212	34.49	34.18	33.98	33.80	33.69	33.57	33.39	33.34	33.31	33.24	33.17	33.11	33.09	32.99	32.94	32.89	32.84	32.80	32.76	32.72	32.68

The following table, based on 12 square feet of heating surface to the horsepower, has been worked out for the ordinary standard sizes of horizontal tubular boilers, in which two-thirds of the convex area of the shell, the combined tube surface and the exposed portion of the heads are considered as the heating surface:

SIZE.	Heating Surface, Square Feet.	Horsepower.
48″ x 16′	762	65
54″ x 16′	891	75
60″ x 16′	990	82
60″ x 18′	1,060	88
66″ x 16′	1,415	115
66″ x 18′	1,600	130
72″ x 16′	1,640	135
72″ x 18′	1,800	150

As an illustration of its use, assume a boiler carrying 100 pounds pressure and having feed water delivered through a heater at 190 degrees F., which evaporates 3,245 pounds of water per hour. Under 100 pounds pressure in the table and opposite 190 degrees will be found 32.45, the number of pounds of water required per horsepower per hour for this temperature of feed and pressure, then $3{,}245 \div 32.45 = 100$ horsepower.

In conjunction with the annual convention of the American Boiler Manufacturers' Association, at Detroit, Mich., Aug. 10, 11 and 12, a meeting will be held of all State and municipal boiler inspectors. Every boiler manufacturer and every State and municipal boiler inspector should plan to be in Detroit on these dates.

Layout of an Intersection Between a Dome and Slope Sheet for a Locomotive Boiler.

BY C. B. LINSTROM.

In some constructions of locomotive boilers it will be found that the dome is located upon the slope sheet, although it is the best practice, when conditions permit, to locate the dome on the fire-box or cylinder connection. The development for this problem may at first appear to the layer-out a very simple matter, but looking further into the subject it will be found that several difficult questions confront him, especially in the case where the horizontal diameter of the boiler is less than that of the fire-box section. This will cause complicated conditions if the layer-out does not keep his wits about him.

Referring to the plan of either Figs. 1 or 3, it will be seen that the slope sheet tapers from a smaller to a large diameter; hence the layer-out will naturally come to the conclusion that

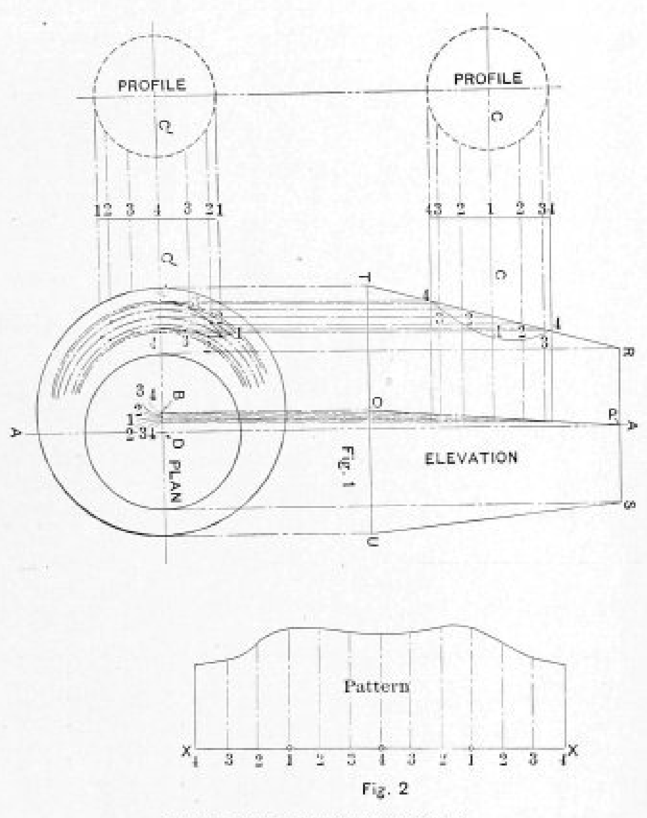


Fig. 2

DEVELOPMENT OF DOME CONNECTION.

the same principles of development can be applied to this object as are used in the development of frustums of cones, and, to a certain extent, the construction is the same, with one exception. Referring again to the plan view it will be seen that the taper is irregular, due to the fact that the respective diameters of the small and large ends do not lie in the same plane. This is clearly shown at *B* and *D*, where *B* represents the axis of the large end and *D* that of the smaller end. If the axis of this object were neutral it could be very readily developed by projection drawing; however, owing to the irregularity it must necessarily be developed by triangulation.

In the development for the dome connection the same irregularity of elements is encountered. It will be noticed, referring to the elevation, that where the dome intersects the slope sheet it will require a development for all the elements, in order to determine the connecting points of intersection between the dome and slope sheet.

It might be well to point out that when drawing the profile for the dome it must be drawn to the inside diameter, otherwise the dome will be entirely out. If the profile is drawn to the neutral axis of the material it will be seen that the quadrant or semi-circle will be greater in circumference, consequently causing a greater pitch of rivets. This will cause the projectors to be too long, consequently throwing out the flange centers.

In the development of these two problems, the thickness of material, spacing of rivet holes, allowance for lap, etc., were not taken into consideration, as these are to be made according to requirements.

CONSTRUCTION OF FIG. 1.

The layout for this condition can be easily obtained by projection drawing. It is first required to draw up the respective views, as shown, to the required dimensions. In this case it is good practice to draw the plan view first and then the elevation.

First draw the line *A-A*; locate upon it the center point *D*, and with a radius of one-half the diameter of the small end, and using point *D* as a center, draw a circle. This represents the small end of the slope sheet. Then draw the center line *C' C'* through point *D* and at right angles to line *A-A*. Locate upon this line *C' C'* point *B*, using *B* as an apex, and with the trammels or compasses set equal to one-half the diameter of the large end draw a circle as shown. Then locate and draw the dome upon the line *C' C'* to the required dimensions. Locate the center of the profile at a convenient distance from the dome and draw the circle. Divide one of its quadrants into any number of equal spaces, in this case three, numbered from one to four, inclusive. Drop these points parallel to the line *C' C'* and make the lines indefinite in length.

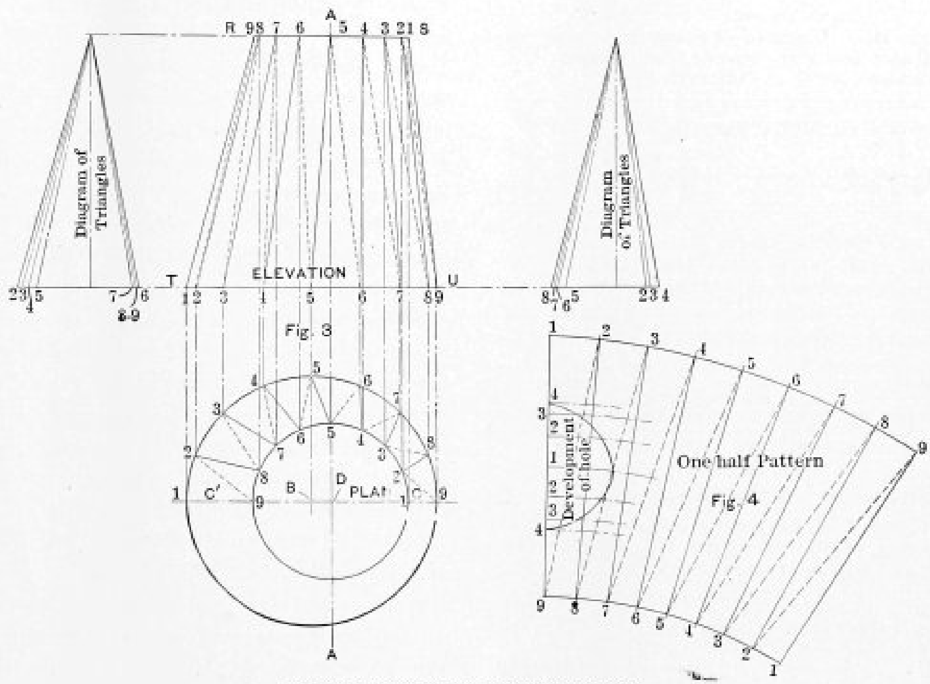
The next procedure will be to develop the elevation. At right angles to the line *C' C'* project the outer points of the circles (that is, where the circles are tangent to the line *C' C'*, to the elevation, as shown at *R*, *S*, *T* and *U*); also project the respective centers of these circles as shown at *P* and *O*. Make the over-all length *S* to *V* equal to the required length of the slope sheet. Connect the points *R*, *S*, *T* and *U* with solid lines, as shown, which show the outer boundary lines of the slope sheet in the elevation. Connect the points *P* and *O* with a construction line; then locate the axis of the dome at right angles to line *S* which is shown at *C-C*. Locate the dome in its relative position to the plan view; then draw the profile and divide the circle into the same number of equal spaces. Project these points parallel with the line *C-C*, and extend them through the line *T-R* until they intersect the line *P-O*. Where these projectors intersect the lines *T-R* and *P-O* determines the respective radii to be used in obtaining the elements and in determining the points of intersection between the dome and slope sheet.

Project the points of intersection between the projectors and the lines *T-R* and *P-O* to the plan view as shown. Set the trammels or dividers equal to the distance between points 4-4, 3-3, 2-2, 1-1, plan view, and draw arcs, using the corresponding points within the distance *B-D* as apexes. Where the arcs intersect with the projectors dropped from the profile plan view determines the cutting plane of the dome. These points are then projected to the elevation until they intersect the corresponding construction lines. Hence the lines from 4 to 4, 3 to 3, 2 to 2, 1 to 1, etc., are the required or true lengths of lines to be used in developing the pattern.

DEVELOPMENT OF THE PATTERN.

Draw the line *X-X*, as shown in Fig. 2, equal in length to the circumference of the dome. This is figured from the neutral diameter, viz.: neutral diameter $\times$ 3.1416 = circumference. Divide this stretchout line into four equal quarters, and space these quarters into three equal parts. At right angles to the line draw the construction lines, indefinite in length. The camber line for the connection is determined by transferring the true lengths of lines from the elevation to the corresponding stretchout lines, thus producing the miter line for the connection. In order to fasten the dome to the shell sufficient material must be added for a flange, which must be turned down by the operation of flanging until it sets uniformly upon the slope sheet. The allowance for flanging will vary according to the thickness of material and diameter of rivet holes. It is the best practice to flange the sheet before punching the holes in the flange. After the allowance for the flange has been determined add for laps, then space off the rivet holes for the vertical and longitudinal connection.

The longitudinal seam in this instance is the connection between the dome and dome head. The line of rivet holes is placed from 1 inch to 1½ inches below the line *X-X*, varying according to the thickness of material and diameter of rivet holes.



DEVELOPMENT OF SLOPE SHEET CONNECTION.

LAYOUT FOR THE SLOPE SHEET CONNECTION.

As pointed out previously, the most applicable method of development for this problem is by triangulation. First draw the plan and elevation identically the same as explained for the development of Fig. 1. It will not be necessary, however, to locate the dome, as it will have no bearing upon the subject, as sufficient data can be obtained from the plan and elevation, Fig. 1, to complete the development for the hole in the pattern.

CONSTRUCTION.

Divide the circles in the plan view into any number of equal spaces, in this instance eight; numbered from one to nine, inclusive. Connect the points with solid and dotted construction lines in order to avoid confusion. Project the points on the large circle at right angles to the line *C C'* until they intersect the lower base of the line *T-U* of the elevation. Project the points from the small circle in the same manner until they intersect the top of the elevation, or the line *R-S*. Connect these respective points with construction lines, as shown.

We now have sufficient data to obtain the true lengths of lines for the development of the pattern. These required lines are shown at the right and left of the elevation, and are designated "diagrams of triangles." The diagram of triangles shown to the left are the dotted and solid lines, or the true lengths of lines, for the foreshortened lines shown on the left of the line *A-A* and those on the right of the elevation are those which are shown on the right of the line *A-A*.

TO LAY OUT THE PATTERN.

First draw the vertical line 1-9 equal in length to the line *R T* shown in the elevation; then set the dividers equal to the space 1-2 of the large circle, plan view, and with 1 in the pattern as a center draw an arc; then with the trammels set equal in length to the dotted line 2 shown at the left of the elevation, strike an arc, cutting the arc previously drawn. Continue in this same manner, using alternately the true dotted and solid construction lines until the pattern is complete. It will be seen that only one-half the pattern is shown developed. As the other half is developed in a like manner it will not need any further explanation.

TO DEVELOP THE HOLE IN PATTERN.

Locate upon the line 1-9 the center for the hole as shown at 1; then locate the points 2, 3 and 4 on both sides of this center. These points are taken from the elevation, and are also located upon the solid lines 2-8 and 7-3 in the pattern. The remaining data for the development are obtained from the plan view. As the operation is so simple it will not require any further comment. Add for laps and locate the rivet holes, then the pattern is complete.

At the annual convention of the American Society for Testing Materials a protest was read from Col. E. D. Meier, chairman of the committee on uniform boiler specifications, regarding the Society's specifications for boiler steel. Col. Meier favored a limit of 0.04 percent on phosphorus and 0.03 percent on sulphur in boiler steel. These limits were adopted by the committee for fire-box steel, but for flange steel the committee's specification allows 0.06 percent phosphorus and 0.04 percent sulphur. In the discussion that followed the point was made on behalf of the steel manufacturers that such refinements in chemical specifications would greatly increase the cost of material for boilers without securing such an increase in safety as the advocates of these severe requirements evidently expected.

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CIRCULATION STATEMENT.

Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

The Importance of Clean Boilers.

Whenever exceptional claims are put forward regarding the performance of a boiler, or whenever the feasibility of a certain form of boiler construction is being considered, almost the first question which a practical boiler maker will ask is, "What kind of water do you have?" "Are you operating in a good-water district or in a bad-water district?" Time and time again we have heard of methods of setting flues or staying crown sheets, or the like, from which remarkable results were obtained, and a little later invariably comes the report that the same methods have proved a failure in some other part of the country. Upon investigation it is usually found that in one case good water has been available, and, consequently, there has been no difficulty in keeping the boiler clean and free from scale, while in the other case, due to poor water, it has been impossible to keep the boiler free from scale and sediment for any length of time. The fact that the kind of feed water used has such an important bearing on the successful operation of a boiler and on the amount and kind of work which is subsequently necessary for up-keep and repairs, makes the question of keeping boilers clean one of the most important which railroad men and the users of stationary and marine boilers have to face to-day. Some pertinent facts in relation to this subject, which deserve more than passing notice, are brought out by the supervisor of boiler cleaning of the New York Central Railroad elsewhere in this issue.

Scale formation and corrosion, due to impurities in the feed water, can be largely overcome in two ways. First, in plants large enough to warrant the expenditure, feed-water softening plants can be installed by means of which, under the care of a competent chemist, all the deleterious impurities can be removed and practically pure feed water can be secured. While such installations have proved economical in large plants, it is doubtful if the initial expense and the cost of operation are justified in small plants. In the latter the only recourse is to add to the feed water in the boiler such reagents as will change the scale-forming impurities into a sediment which can easily be washed out of the boiler, and which will neutralize the corrosive acids in the water. Such reagents can be readily obtained and utilized with the expenditure of only a small amount of time and money, soda ash being perhaps the most common and effective of any of those in general use, but it is foolish to expect that the indiscriminate use of any such remedy will accomplish the desired result in every case. Few samples of feed water show the same chemical analysis, and unless the proper quantity of soda ash (or other reagent) is used scale and corrosion will not be prevented. In short, the quantity is quite as important as the quality.

With means at hand for determining when the proper quantity of such reagents is being used, there would be little excuse for dirty boilers to-day, even in bad-water districts. Trial and experience will often give fairly accurate information on this point, but for satisfactory results some sort of a chemical analysis is necessary, and to the average engineer this is a difficult problem. We believe there is nothing which will better repay every steam user than a thorough investigation of this question as it applies directly to his own case. If boilers were kept uniformly clean, one of the most disturbing elements in the comparison of various steam boiler practices would be eliminated. Likewise, many of the troubles of the boiler maker would also disappear.

From the Master Mechanics' Convention.

Several topics of immediate interest to boiler makers were discussed at some length at the recent convention of master mechanics in Atlantic City. Perhaps the most important is that relating to mechanical stokers. With possibly one or two exceptions mechanical stokers for locomotives are still in the experimental stage, and the amount of actual data covering their operation is very meager. The committee investigated every type of stoker which has reached an interesting stage of development, but with one exception was unable to procure any figures of tests. The results in this case were not favorable to the stoker. One engine showed an increase of .734 percent in equivalent evaporation per pound of combustible with the stoker, while another engine showed a loss of 11.16 percent; in the latter case, however, a large proportion of fine coal was used, which accounts in part for the poor showing. With the first engine the stoker showed a loss of 17.02 percent in combustible hours per ton-mile, while with the second engine the combusible hours per ton-mile was only 8.7 percent greater with the stoker. It is not surprising that these early tests of mechanical stokers fail to show good economy as compared with hand firing. The principal reason for developing the mechanical stoker is not merely to get increased efficiency of coal consumption but to enable a higher rate of combustion to be maintained on a larger grate than is possible with hand firing. This the experiments seem to indicate will be entirely feasible, and, moreover, the experiments show that the fire in such a case will be maintained in good condition from the beginning to the end of a run, with little if any variation in the steam pressure, and that the same type of engine which is now fired by hand will be able to do considerably more work when fired by a mechanical stoker. Questions of repairs and reliability seem to have been satisfactorily met so far.

In discussing the question of whether or not the additional cost of flexible stay-bolts is justifiable it was brought out that a universal method of applying flexible stay-bolts would be desirable. One instance was given where cracking of the side sheets was obviated by applying flexible bolts in the center of the side sheets about 18 inches above the mud-ring where cracks were found to develop. This is an unusual application of flexible stay-bolts, but as it was successful it shows that the possibilities of this form of staying flat surfaces are by no means exhausted.

Another important subject which was brought up was the question of using brick arches and watertubes in locomotive fire-boxes. From the splendid results which have been obtained with these devices it is apparent that if any attempt is to be made to increase the efficiency of a locomotive boiler this means cannot be disregarded. A saving of coal consumption is almost sure to result from the application of the brick arch, and if watertubes are used the increased circulation will have a good effect in prolonging the life of the fire-box. Difficulties regarding the maintenance of brick arches are gradually being overcome. A valuable suggestion in this direction was given by Professor Hibbard, who showed that fire-bricks for locomotives should have a greater degree of toughness and less ability to stand high temperatures. The temperature in the locomotive fire-box is low compared with that in many other places where fire-brick is used, but the mechanical abuse of the brick in a locomotive fire-box is very severe, and, therefore, better results would be obtained with a tough fire-brick rather than with a high- temperature fire-brick.

COMMUNICATION.

Regarding the I. M. B. M. A. Report on Standard Punches, Dies and Couplings.

Editor The Boiler Maker:

Two errors were made in the printed report of the committee on standard boiler-shop tools, machinery and equipment which was presented at the last annual convention of the International Master Boiler Makers' Association. These errors subsequently appear in the abstract of this report, which you published on page 192 of your July, 1909, issue. In the illustration showing style "A" punches and system of sleeves on page 193, the cuts for punches Nos. 5 and 6 have been transposed. The punch numbered 5 is really punch No. 6, and *vice versa*. Similarly on the same page the cuts showing the key to the table for "A" and "B" punches have been transposed, style "A" punch as shown there really being style "B."

T. C. Best.

PERSONAL.

W. M. Wilson, formerly chief boiler inspector of the Illinois Central, has been made master boiler maker of the El Paso & Southwestern Railroad, at El Paso, Tex.

A. Barber has been made assistant master boiler maker of the El Paso & Southwestern Railroad, at El Paso, Tex., vice E. A. McIntyre, resigned.

P. S. Morrison is general foreman boiler maker of the Rock Island shops at Silvis, Ill.

J. H. Smythe, formerly inspector at the Schenectady shops of the American Locomotive Company, has just been appointed general foreman of the Pittsburg shops of this company. Mr. Smythe was for many years general foreman boiler maker of the Rogers works of the American Locomotive Company at Paterson, N. J.

E. W. Rogers, formerly general foreman boiler maker of the Cook works of the American Locomotive Company at Paterson, N. J., has been transferred to the Rogers works of that company at Paterson.

J. T. Goodwin has severed his connection with the American Locomotive Company at Richmond, Va., and for the present his plans for the future are undecided. Mr. Goodwin has long been identified with the boiler-making industry, and has been one of the foremost workers in the International Master Boiler Makers' Asociation, holding at the present time the responsible office of chairman of the executive committee. He is a former president of the International Railway Master Boiler Makers' Association, and for a long time served as its secretary and treasurer, being largely instrumental in bringing about the consolidation of this organization with the Master Steam Boiler Makers' Association, forming the present International Master Boiler Makers' Association. Mr. Goodwin has a wide acquaintance among both railway and contract boiler makers, and his many friends will wish him success in whatever he undertakes in the future.

Boiler Manufacturers' Convention.

The programme for the twenty-first annual convention of the American Boiler Manufacturers' Asociation of the United States and Canada, to be held at the Hotel Pontchartrain, Detroit, Mich., Aug. 10, 11, 12, 1909, is as follows:

TUESDAY, AUG. 10, 10.00 A. M.

Calling of convention to order by President Col. E. D. Meier.

Address of welcome to city, Hon. Phillip Breitmeyer.

Reply to address of welcome, Col. E. D. Meier.

Report of committee on topical questions and discussion of same.

TUESDAY, AUG. 10, 2.00 P. M.

Report of executive committee.

Appointment of committee on place of next meeting, nominating committee, auditing committee.

Report of committee on membership.

WEDNESDAY, AUG. 11, 9.00 A. M.

Report of nominating committee.

Report of auditing committee.

Report of committee on place of next meeting.

Report of committee on uniform specifications.

Discussion of important questions relative to boiler inspection and construction, as viewed by members of this association and municipal inspectors.

THURSDAY, AUG. 12, 10.00 A. M.

Executive session.

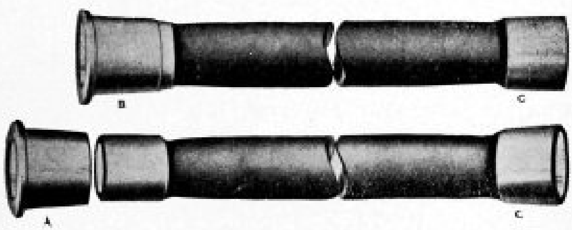
THURSDAY, AUGUST 12, 2.00 P. M.

Unfinished business.

ENGINEERING SPECIALTIES.

A Detachable Boiler Flue.

The Detachable Boiler Flue Manufacturing Company, Minneapolis, Minn., have on the market a flue which they claim can be removed from a boiler, cleaned and replaced by any inexperienced man in a very short time. The advantage of this, when it is remembered how rapidly locomotive and other boiler flues become incrusted with mud, scale and other deposits necessitating the removal of the flue, is clearly apparent. From the illustration it will be noted that both ends of the detachable flue are heavily reinforced and tapered. After the old flues are removed from the boiler the holes are reamed to exactly the same taper as the flue ends, but large enough to admit of the insertion of a copper ferrule into which the tapered flue ends will fit snugly. The end marked *C* is inserted through the hole in the front boiler plate, passed through the



boiler, and through the corresponding hole in the fire-box tube plate. A split ferrule is then slipped around the tapered end of the tube, and both the tube and ferrule are driven back snugly into place, making a tight joint. The part marked *A* is the tapered sleeve, which, with a copper ferrule, is inserted in the front tube plate. The inside of this sleeve and the tapered end of the flue are carefully ground, so that when fitted together a tight friction joint results. It is claimed that no pressure can loosen this sleeve joint, and in case a leak occurs at the fire-box end a sharp blow with a hammer on the part marked *C* will effectively stop the leak. It is also claimed that no amount of hammering on the end marked *C* will drive the sleeve *A* back out of position.

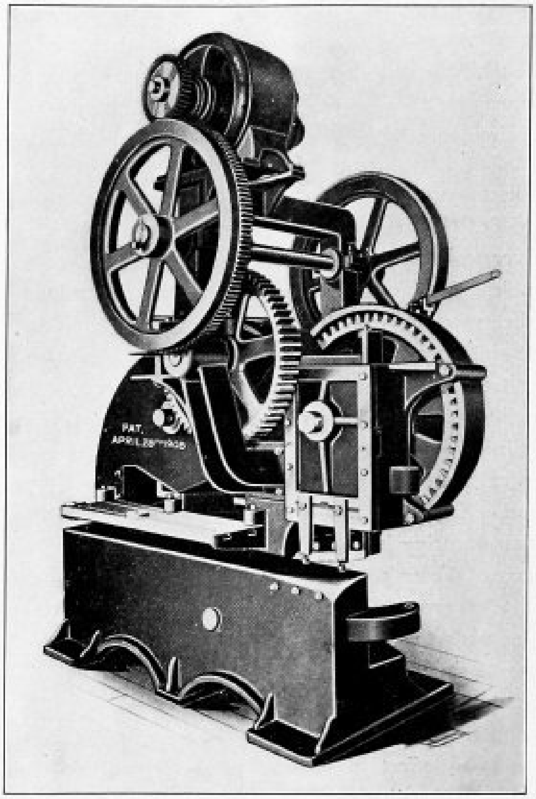
One of the principal advantages of this type of flue is the fact that when a leak develops it is not necessary to draw the fire and allow the boiler to cool down so that a boiler maker can go into the fire-box and expand and calk the flues. It is simply necessary to put a "flue-seating iron" through the fire-box door into the end of the flue and hit it a sharp blow with a hammer, when the leak will be stopped.

A Universal Plate, Bar and Angle Shear.

To cut angles or plates on an ordinary punching and shearing machine requires considerable changing, which consumes time. A machine which is always ready for any kind of work, and is, therefore, a great labor-saving tool, is placed on the market by the Covington Machine Company, Covington, Va. In this machine a plate shear is placed on the front of the machine with angle shears in two square openings in the side. The latter will cut right and left angles of even or uneven legs to any angle up to 45 degrees. The shears are all driven from one pulley or motor. The angle shears, with their knives, travel in angles of 45 degrees with the horizontal, and the plate and angle shears can be operated singly or together. A patent clutch mechanism, which contains no springs to keep up a continual knocking of the jaws, is arranged to positively stop at the highest point of the stroke. The clutch lever is universal, and can be swung to any position to suit the operator.

It has always been a difficult matter to cut angles with uneven legs, unless large special machines, too expensive for ordinary manufacturers, have been installed for this purpose. It is claimed that this shear embodies all the best features of a double-angle shear, and also the best features of a plate and bar shear. Bars may be cut by either the angle or plate shear.

The machines are designed to occupy the minimum of room, are strongly geared, and of massive design throughout. The



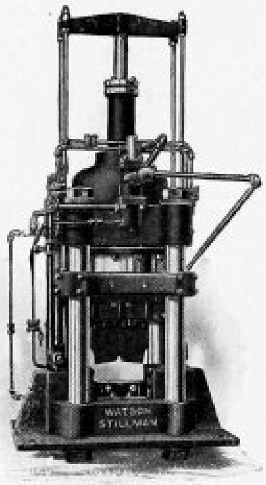
gear covers, besides acting as safety guards, form the bearings for the gears, and the gears in turn form the bearings for the eccentric shafts, so that by this method a maximum stiffness of design and protection for the workmen are secured.

The Watson-Stillman Hydraulic Beam Shear.

A new hydraulic beam shear, for cutting I-beams, channels, tees, flat bars, angle-irons, corrugated channels, Z-bars and other structural shapes has just been placed on the market by the Watson-Stillman Company, New York City. The shear may also be used to cut round and similar sections in emergencies, when the regular machines for that purpose are in use, and by removing the cutting mechanism it is readily converted into a powerful hydraulic press for general work. With this machine it is claimed that a simple foot pressure and the manipulation of a hand lever enable an inexperienced operator to cut structural sections as fast as they can be brought into position. One setting and operation of the machine make the entire cut; thus no time is lost, as where the cut is made by a series of chops, or as when half is cut and the beam must be turned over and reset before the other half can be cut.

The machine is made in two sizes, to take beams and similar sections having a longest dimension of 15 inches and 24 inches, respectively. Both sizes are made for an operating pressure of 1,500 pounds per square inch in the operating cylinder, but the machine can be furnished with cylinders of suitable size for any pressure from 1,000 to 3,000 pounds. In shops where the line pressure falls below these figures the machines may be operated through an intensifier. If sections varying greatly in size are to be sheared, there is some advantage in using a variable pressure intensifier, as this permits operating at low-pressures and saving power when the work is small.

The steel frame and cylinders are much more compact than in similar machines made of cast iron, and the smaller moving



parts effect a big power saving. As will be seen from the illustration the upper cutting knives are of a unique construction, which possesses decided advantages over the solid knives ordinarily used. The beam is supported from underneath and at the sides by double stationary knives which conform to its shape, and which form a slot into which the upper knives descend. During the cutting operation the lower knives are, of course, supported by the lower platen, while those at the sides of the beam are wedged into a position which gives them the solid backing of the machine frame. As the upper knives descend they pass first through the web of the beam and into the slot between the lower knives. As they continue to descend they are parted by the dividing post, and swinging outward, pass through the flanges. It is evident that all parts of the cut are therefore made directly against solid backing and through a practically equal thickness of metal at all points.

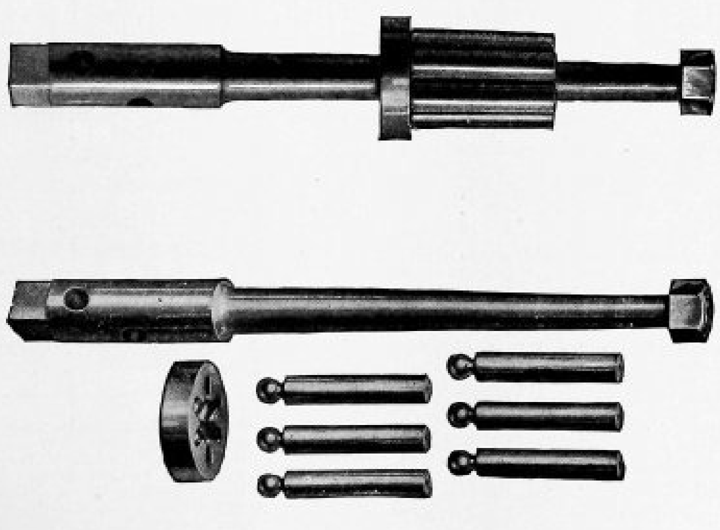
The gripping and releasing of the beam before and after cutting are entirely automatic, these operations being controlled by the operation (by a hand lever) of two auxiliary cylinders.

In operation, hydraulic pressure is first admitted to the auxiliary cylinders, forcing the two clamping wedges on which the outer shears are mounted to grip and hold the beam with all the rigidity of the press frame. Hydraulic pressure is then admitted to the main cylinder, causing the ram to descend and drive the shearing knives first through the web of the beam, then, as they are parted by the driving wedge, through the flanges of the beam.

It is claimed that any set of cutting knives may be removed and replaced in five minutes by those for another size section, and that the knives do not need to be sharpened often, since slight dullness does not interfere with the capacity of the machine. In the event of the breaking of the knives, which comprises a large part of the cost of up-keep in heavy beam shears, it is claimed that the construction of divided blades used in this machine permits the knives to be reground or replaced at less cost and with less labor than with solid blades.

The Nicholson Tube Expander.

The Nicholson boiler tube expander, which is manufactured by W. H. Nicholson & Company, Wilkesbarre, Pa., is of the self-feeding roller type, and can be operated either by power or by hand. The tool consists of a mandrel, the end of which is fitted for receiving an air motor or for hand driving, on which is carried a collar holding six rollers in ball and socket joints. The fact that the tool has six rollers gives it an exceptionally large bearing in the tubes, so that it is necessary to exert only a small amount of power in rolling a tube. It is claimed that one man can easily expand a 4-inch tube by hand. The additional rolls also insure that the expander will roll the tube tightly without the possibility of over-rolling and ruining the tube. As the rolls are held in ball and socket joints the tool is both self-feeding and self-releasing, all that is necessary to release the tool being to reverse the rotation of the arbor. The expander is made of the best tool steel, throughout carefully hardened.



Little Giant Portable Punches and Shears.

The Little Giant Punch & Shear Company, Sparta, Ill., manufacture a large number of different types of portable punches and shears suitable for light sheet metal and boiler work. The tools are operated by hand, but through a powerful system of levers the force applied on the punch or the shear is large, enabling machines of comparatively light weight to

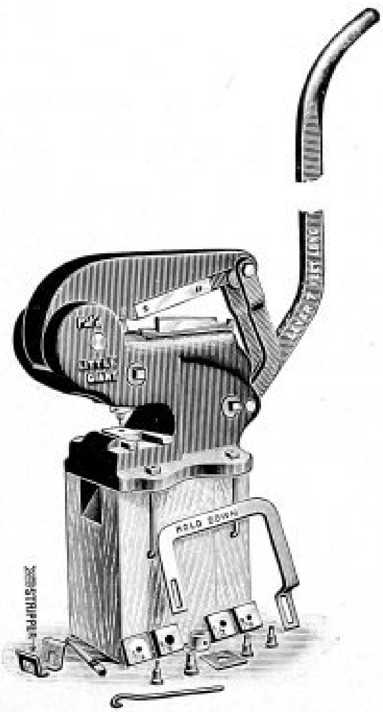


FIG. 1.

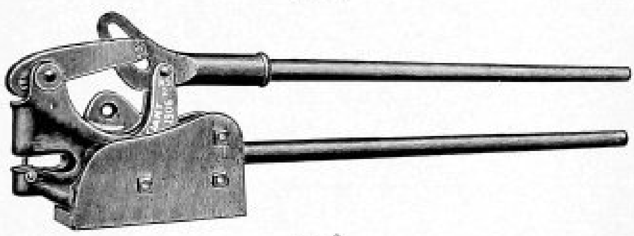
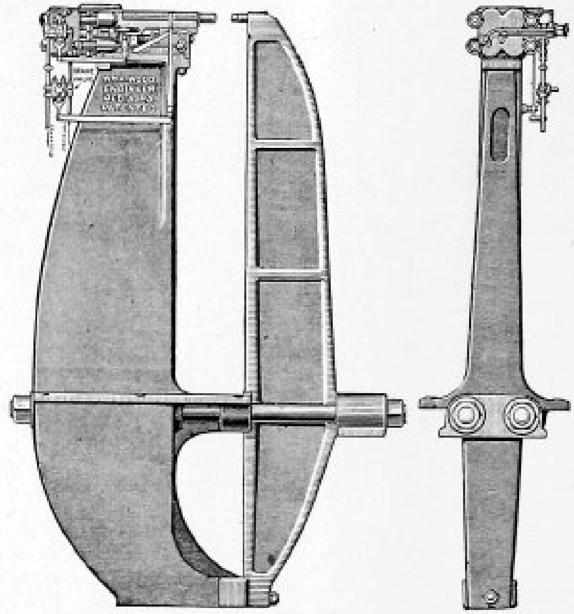


FIG. 2.

punch ¼-inch holes in ¼-inch steel. Fig. 1 shows a combined punch and shear, which is suitable for blacksmiths, wagon makers, implement manufacturers and all heavy metal workers, while Fig. 2 shows the Little Giant quick-action portable punch, capable of punching ¼-inch holes in ¼-inch iron. This tool weighs only 16 pounds, and as the handles are removable it is of convenient size for packing in a satchel or tool chest. It is also provided with a bench or post attachment for shop use.

W. H. Wood's Improved Hydraulic Riveters.

The illustration shows one of the new hydraulic riveters which is manufactured by William H. Wood, Media, Delaware County, Pa. This riveter can be packed without removing the heads, as it is entirely outside-packed. It is fitted with quadruple plungers of equal area and diameter, so that the plungers are all interchangeable. The plungers can also be detached from the main part of the head of the riveter; therefore the riveter will retain perfect alinement. The cylinders are fitted with a distributing valve attached to the balanced main valve for operating them. Three pipe connections work the four plungers. That is, when working with 50 tons pressure the valve is set to the central pipe, which connects with the two opposite cylinders. When working with 25 tons pressure it is set to the top pipe, and when working with 75 tons pressure it is set to work by the central and top pipe connection. Finally,



when working with 100 tons pressure the valve is set to work from all three pipe connections. The push-back cylinder is arranged in such a way as to practically balance the driving head. The four plungers are all 6¾ inches in diameter, and with a hydraulic pressure of 1,500 pounds per square inch a total pressure of 100 tons can be obtained. The riveter has an adjustable stroke up to 6 inches, and is made in sizes up to 18 feet 6 inches gap.

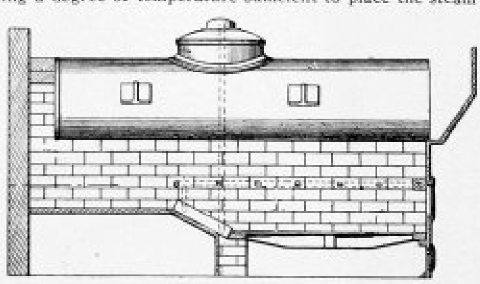
SELECTED BOILER PATENTS.

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

924,805. FUEL-ECONOMIZING APPARATUS FOR FURNACES. HARRY LUCKENBACH, OF NEW YORK, N. Y., ASSIGNOR TO ISAAC R. COLES, OF GLEN COVE, N. Y.

Claim 3.—In a fuel-economizing apparatus for steam boiler furnaces, the combination with the fire-box and a natural draft therefor, of a superheater exposed to the fire and comprising means for continuously maintaining a degree of temperature sufficient to place the steam in a hot



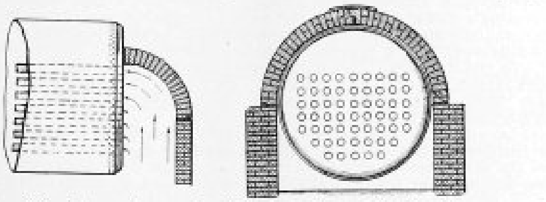
dry condition susceptible to ready decomposition, a distributing pipe receiving the steam from the superheater and having sections embedded and sealed from air in the walls of the fire-box, and a plurality of delivery nozzles coupled to each distributing pipe section and also sealed from air and embedded in the fire-box walls, each distributing nozzle having an outlet orifice for jetting the steam in the combustion chamber at a point above the fire therein. Five claims.

925,076. SUPERHEATER BOILER. JOHN E. BELL, OF NEW YORK, N. Y., ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

Claim 1.—A superheater boiler having transverse steam and water drums connected by banks of tubes to a lower transverse mud drum or drums, a single furnace in front of the boiler having an arch, and a superheater over the arch located in a by-pass for the gases. Two claims.

925,519. BOILER SETTING. JOHN H. SIMPKINS, OF UHRICHSVILLE, OHIO.

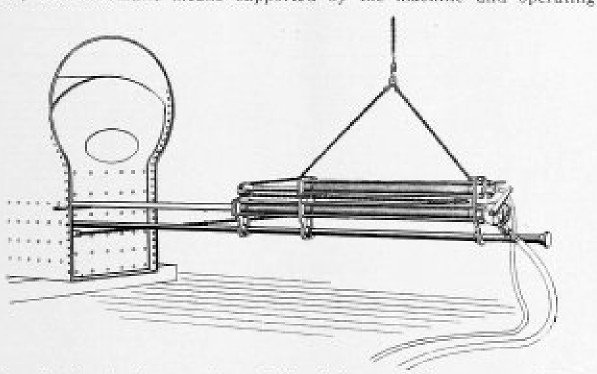
Claim 2.—A boiler setting comprising inclosing walls, a plate on the upper edge of each of said walls formed with a shoulder and an inclined face thereon, a boiler, lagging position thereon, arch sections arranged upon said boiler and being constructed on their lower edges to



rest upon said plate and to rock thereon against said shoulder toward said inclined face, and their upper edges being provided with a lap joint, whereby said arch sections may rock under the influence of the expansion of the boiler. Two claims.

925,491. MACHINE FOR SEVERING STAY-BOLTS. GROVER S. LOWE, OF MOLINE, ILL., ASSIGNOR TO WILLIAMS, WHITE & COMPANY, A CORPORATION OF ILLINOIS.

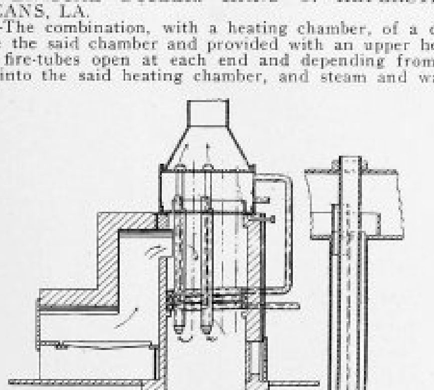
Claim 1.—A machine of the type described including in combination means for positioning the machine for severing a series of bolts, a bolt cutter, and automatic means supported by the machine and operating



independently of the actuation of the bolt cutter for progressing the cutter from one bolt to another as they are cut. Twenty-nine claims.

925,107. VERTICAL BOILER. HANS O. KEFERSTEIN, OF NEW ORLEANS, LA.

Claim 1.—The combination, with a heating chamber, of a drum supported above the said chamber and provided with an upper head and a lower head, fire-tubes open at each end and depending from the said upper head into the said heating chamber, and steam and water tubes



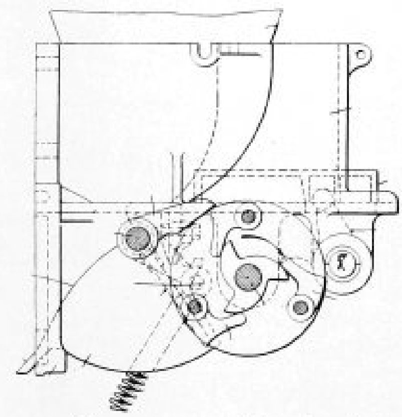
encircling the said fire-tubes and secured in the said lower head and provided at one side of their upper ends with inlets for water, which communicate with the water space of the drum, and provided also at their other side portions with outlets for steam arranged above the level of the said inlets for water, and communicating with the steam space of the drum, said steam and water tubes being closed at their lower ends. Four claims.

925,283. METHOD FOR PREVENTING THE FORMATION OF BOILER SCALE. THEODOR BRAZDA, OF AMSTETTEN, AUSTRIA-HUNGARY.

Claim 2.—A method for preventing the formation of incrustation in boilers and other receptacles, consisting in partially filling with feed water a receptacle closed on all sides and shut off from the feed pump and the boiler, the contents of the receptacle being at the start free from pressure above that of the atmosphere, in vigorously stirring the feed water in the receptacle, in simultaneously heating the feed water in the receptacle, and continuing the stirring and heating until the feed water is thoroughly boiled and the temperature of the feed water equals that of the water in the boiler, whereby a part of the hardening agents is precipitated, and then introducing the precipitates into the water in a boiler or other receptacle. Four claims.

917,750. MECHANICAL STOKER. JOHN CALDWELL, OF MONTCLAIR, N. J.

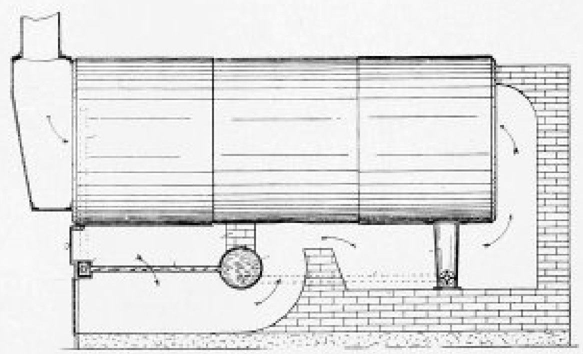
Claim 2.—An automatic stoker comprising a ram compartment, a shovel compartment below the same and in communication therewith, the side walls of the shovel compartment being formed with permanent and renewable sections and provided with shaft openings near their upper edges, said walls being divided on a line extending from the forward upper edge thereof through the shovel shaft opening to the inner or rear edge of the bottom, the removable lower sections of the side



walls being connected by a transverse wall section, a horizontal shaft in the shovel compartment and extending through the side walls thereof, a shovel secured to said shaft within the shovel compartment, and means for detachably connecting together the forward edge of the permanent part of the shovel compartment to the forward edge of the removable part thereof. Three claims.

917,751. DOWNDRAFT BOILER. CHARLES NIPRESS CHANDLER AND GEORGE DOW, OF YARRAVILLE, VICTORIA, AUSTRALIA.

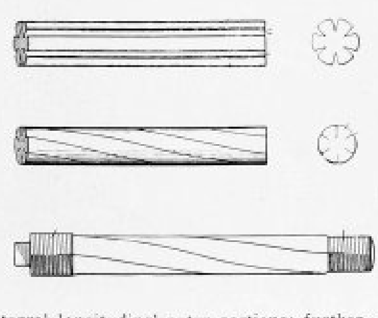
Abstract.—A furnace comprising a boiler, a fire room located below the same, a transverse tube extending across the top of the fire-room, said tube having its front face removable, a transverse cylindrical tube in the rear of the fire-room, tubes connecting the tube with the tube and acting as grate-bars, a wall supported on the tube and extending up



to the bottom of the boiler, a conduit for the products of combustion leading from the fire-room below the tube past the rear of the boiler and to the chimney, a vertical blowoff tube in said conduit and extending downwardly from the bottom of the boiler, a pipe connecting the tube with said tube, a cock in said pipe, a pipe connecting the upper part of the boiler with the tube, and a cock in said pipe.

918,193. STAY-BOLT FOR STEAM BOILERS. FRANKLIN M. PATTERSON, OF PHILADELPHIA, PA.

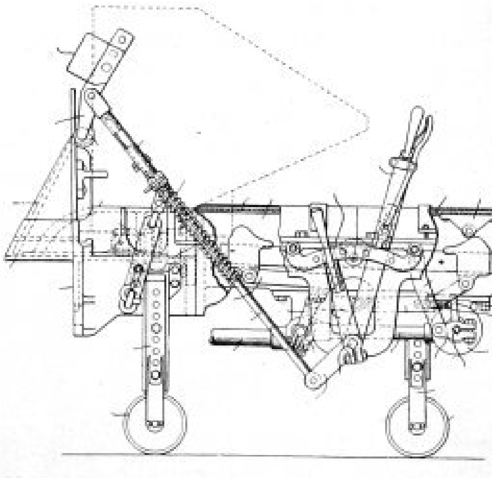
Abstract.—The invention consists of a stay-bolt formed of a single rod of metal having radial incisions extending from the outer surface inwardly for part of the radial distance and forming a solid core with



a series of integral longitudinal outer portions; further, in the structure above specified when twisted upon itself so that the longitudinal outer portions assume a helical form about a straight core; further, in the construction last stated when screw threaded for engagement with the sheets of the boiler. Eleven claims.

918,217. MECHANICAL STOKER. WILLIAM H. STROUSE, OF OSKALOOSA, IA., ASSIGNOR TO AMERICAN AUTOMATIC STOKER COMPANY, A CORPORATION OF ARIZONA TERRITORY.

Claim 1.—In a mechanical stoker, the combination with a reciprocatory plunger having its forward end formed to project the fuel, the door controlling the opening through which the fuel is advanced by the plunger and a cylinder and piston for moving said plunger, of a valve mechanism controlling the admission and exhaust ports of the cylinder, a pivoted trip bar connected with the admission valve for operating the latter, means intermediate said bar and plunger for moving said trip bar about its pivot in opposite directions, a throttle valve, a hand lever



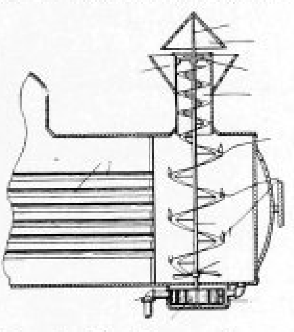
controlling the same, connections intermediate said hand lever and admission valve, whereby when the throttle is closed the admission valve is moved to prevent the entry of steam at one end of the cylinder and connection intermediate said hand lever and door for closing the door when the throttle is closed. Eight claims.

918,260. STEAM BOILER. PIERRE BARNES, OF SEATTLE, WASH.

Claim 1.—In a steam boiler, the combination, with series of inclined water tubes, of separate headers connected to the opposite ends of each of said series of tubes and arranged at different elevations, a water drum and a separate steam drum, the former being arranged below and connected to both the upper and the lower headers, while the latter is arranged above and connected only to the upper headers. Three claims.

918,290. SPARK ARRESTER. GERRIT DAM, OF MONSEY, N. Y.

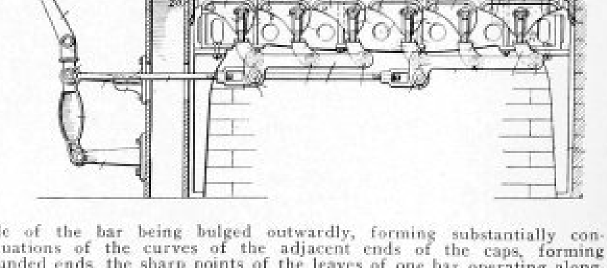
Claim 2.—In a device of the character described, the combination with a furnace, and a stack disposed in operative relation to said furnace, of a fan disposed beneath said stack a spiral strip disposed above said fan in said stack, a plurality of wings disposed on said strip, a shaft



for supporting said fan and said strip, means for actuating said shaft to cause said strip and said fan to force gases from said furnace through said stack, and means disposed upon the upper extremity of said stack for engaging and holding cinders carried by the gases. Two claims.

918,317. GRATE. CHARLES W. HARVEY, OF NEW BRUNSWICK, N. J.

Claim 1.—In a grate, the combination with spaced rotatable bars, of leaves detachably mounted on the bars and projecting on opposite sides of the same, each of said leaves having a widened cap on its upper edge provided with downwardly curved ends, the leaves tapering from the caps toward their lower ends, the end edges of the leaves on one side of each bar being curved inwardly from the ends of the caps to produce sharp points at said ends, the opposite end edges on the other



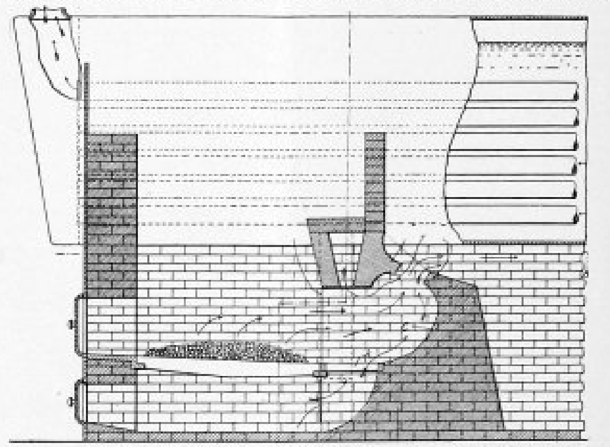
side of the bar being bulged outwardly, forming substantially continuations of the curves of the adjacent ends of the caps, forming rounded ends, the sharp points of the leaves of one bar operating alongside the rounded ends of the leaves of the adjacent bar, and means for rocking the bars from a central position in opposite directions to raise either the pointed ends, in order to cut into the crust of the fire above them or to elevate the rounded ends to stir the fire and prevent its dropping through the grate. Three claims.

918,411. BOILER-TUBE EXTRACTOR. WALTER T. ADAMS, OF HAYS BOROUGH, PA., ASSIGNOR OF ONE-HALF TO RICHARD HIGGINS, OF PITTSBURG, PA.

Claim 3.—An apparatus for withdrawing boiler tubes, comprising a frame consisting of diverging arms, and a central internally threaded bearing, a hollow screw extending through said bearing, a jack for revolving said screw, a rod adapted to extend through said screw, and through a boiler tube, said rod having a plug at one end provided with projecting cutters, and a clamping device adapted to secure said rod, and subsequently a boiler tube to the hollow screw. Three claims.

918,518. SMOKE CONSUMER. RICHARD JOHN WALTER DWINNELL, OF MONTREAL, QUEBEC, CANADA, ASSIGNOR TO THE PERFECT SIMPLEX COMBUSTION COMPANY, OF MONTREAL, CANADA.

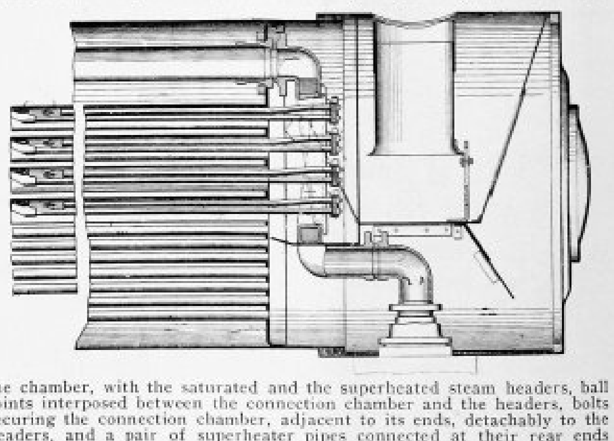
Claim 1.—The combination with the fire chamber and bridge wall of a furnace, of a transverse baffler extending downwardly from the roof of the fire chamber and adjacent to the bridge wall, a fire grate extending between the front of the fire chamber and bridge wall and beneath



the baffler and presenting a passage therebetween and the said baffler, and means projecting from the said baffler and contracting the upper portion of the passage between the baffler and bridge wall to less capacity than the lower portion of such passage. Eight claims.

918,881. STEAM BOILER SUPERHEATER. CARL J. MELLIN AND FRANCIS J. COLE, OF SCHENECTADY, NEW YORK, ASSIGNORS TO AMERICAN LOCOMOTIVE COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

Claim 3.—In a steam boiler superheater, the combination of a saturated steam header, a superheated steam header, a connection chamber located in front of said headers and having a saturated and a superheated steam compartment, communicating, respectively, at the ends of



the chamber, with the saturated and the superheated steam headers, ball joints interposed between the connection chamber and the headers, bolts securing the connection chamber, adjacent to its ends, detachably to the headers, and a pair of superheater pipes connected at their rear ends and communicating, at their forward ends, with the compartments of the connection chamber. Seven claims.

918,900. STEAM-PRESSURE GAGE. GUSTAVE C. OSTERMANN, OF SYRACUSE, N. Y., ASSIGNOR TO SYRACUSE STEAM GAUGE MANUFACTURING COMPANY, OF SYRACUSE, N. Y., A CORPORATION OF NEW YORK.

Claim.—In a steam gage, a circular case having an opening in its bottom, a threaded nipple extending through said opening and provided with a head secured to the bottom of the casing, said nipple being provided with a steam inlet passage, a pair of arms secured to and rising from the head, a dial secured in the front side of the case, a spindle journaled in the arms, an index finger secured to the spindle and movable around said dial as the spindle is rotated, a pinion on the spindle between said arms, a bell crank lever fulcrumed upon and between said arms below the spindle, and having an upright arm provided with a toothed rack engaging with said pinion, said bell crank lever having a lower arm extending laterally from the fulcrum, an auxiliary arm adjustably secured to said lower arm, a hollow segmental spring having its lower end secured to the head and communicating with the inlet, said spring rising from the head substantially concentric with the spindle and having its upper end terminating at approximately the highest point of its arc, and a link connecting the upper end of said spring with the adjustable arm of the bell crank lever. One claim.

THE BOILER MAKER

SEPTEMBER, 1909

HEAVY WORK THE RULE IN A MARINE BOILER SHOP.

BY JAMES J. FLETCHER.

As shown by the photographs herewith reproduced, which were taken recently at the shops of the Manitowoc Boiler Works Company, Manitowoc, Wis., most of the work done in a marine boiler shop is of a heavy nature, requiring machine tools and other equipment of large capacity and high power. At the time of writing, three large marine boilers of the Scotch type were under construction, three of them 13 feet 3 inches in diameter, for a working pressure of 180 pounds steam, for the steamer *United States*. Two others 14 feet diameter, for 178 pounds steam, were also under construction for the S. S. *Kearsarge*, of the Canada Atlantic Line of boats, operated by the Grand Trunk Railway. The boilers were 14 feet diameter by 13 feet 6 inches long, having three Morison furnaces pear-shaped at the combustion chamber end. This shape permits easy removal of the furnaces from the boiler, if so required. These furnaces are attached to one combustion chamber and are 44 inches in diameter. The hot gases are led back through two hundred and fifty-four

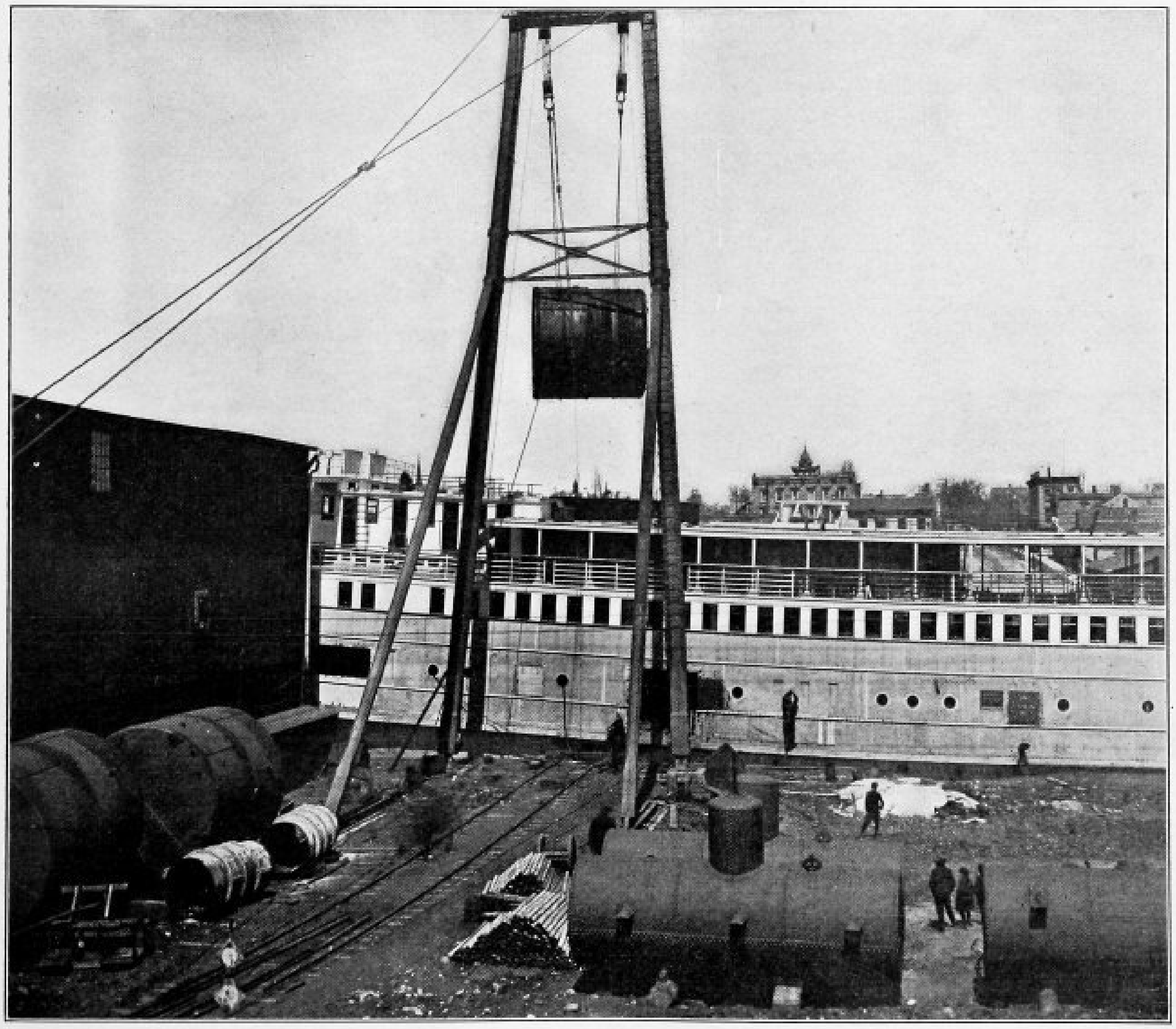


FIG. 1.—PLACING A 50-TON SCOTCH BOILER ABOARD THE S. S. UNITED STATES.

3½-inch tubes in each boiler, thirteen of these being stay tubes. Natural draft is to be used, and the boilers weigh, approximately, 50 tons each. They are set thwartships in the boat, with the breeching connected in the center to one stack.

The other boiler, shown in the photograph, is for the Government Survey boat *Engineer*. It is 11 feet in diameter by 11 feet 6 inches long, with two Morison furnaces 43 inches in diameter. These furnaces are also made for removal at any time without molesting any other part of boiler. It has one hundred and sixty 3½-inch tubes and one combustion chamber. It is designed for a working pressure of 150 pounds steam, and uses natural draft. The total weight of the boiler is about 32 tons.

Fig. 1 shows the shear legs, installed at these works, lifting the boilers and placing them in the hull of the *United States*. These are perhaps the best shear legs on the Great Lakes for placing or taking out marine boilers. These boilers each weighed about 43 tons, and they were placed in the boat in a very short time without any trouble at all.

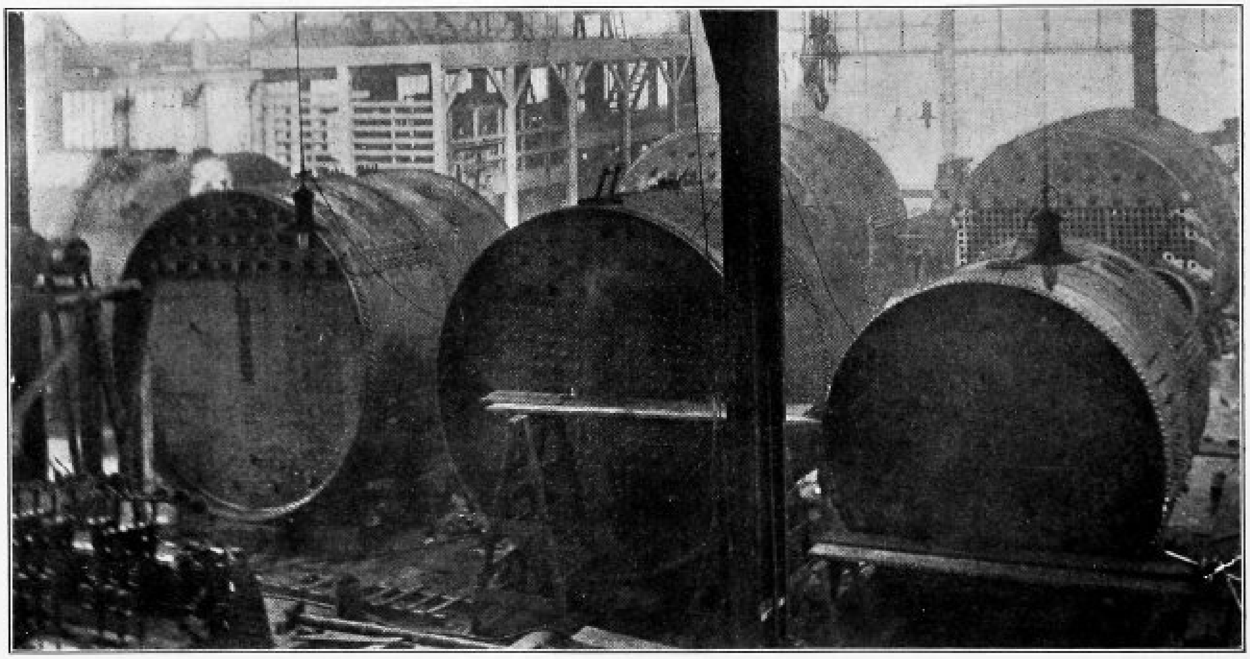


FIG. 2.—INTERIOR OF MANITOWOC BOILER SHOP, SHOWING WORK IN PROGRESS.

NOTES ON ENGLISH LOCOMOTIVE BOILERS.

In a paper read before the Institution of Mechanical Engineers, July, 1909, Mr. George Hughes, chief mechanical engineer of the Lancashire & Yorkshire Railway, of Horwich, England, discussed the design and performance of various types of locomotives in use on the railroad with which he is connected. The Lancashire & Yorkshire Railway Company possess 1,517 locomotives, 1,052 of which have been constructed at the Horwich works. Approximately, 1,100 engines are in use daily, the number varying, of course, with the demands of traffic.

When the works at Horwich were opened the company had 1,000 engines, 353 of which were passenger engines and the rest freight engines. There were twenty-nine different types of passenger engines and twenty-six types of freight engines. An attempt was made at that time to reduce the number of types to as few classes as possible and to introduce standardization, and, wherever possible, interchangeability.

As a result of this policy for a number of years, until the introduction of larger types of locomotives, the flanged plates were common to each class of boilers, with only a slight difference in the length of the barrels. When the larger types were introduced, however, this uniformity disappeared, and Figs. 1 to 10 illustrate the different boilers for various classes of engines.

DETAILS OF BOILERS.

In the first boilers with round top fire-boxes, experience proved that the tubes were placed too near the bottom and sides of the barrels, as pitting soon developed, especially in the neighborhood of the smoke-box tube plate. Subsequent boilers were built with a fewer number of tubes, so as to give greater distance between the tube and barrel, and more recently the distance between the tubes has been increased from 9/16 inch to 11/16 inch. In 1896 the Belpaire type of fire-box was introduced into a number of shunting tank engines. This type of box had advantages in the way of increased steam and water space, additional surface on the back plate for mountings, and direct staying of the crown. A similar design, of suitable proportions, was adopted for the large engines. With these boilers it was impossible to introduce the inside box from the bottom, and Mr. Aspinall decided to pass it in from the back, and flange the back plate outward, for convenience of riveting up by machine. This method of flanging cured more than one evil, but resulted in setting up severe stresses in the crown sheet along the line of rivet holes which join the back plate to the wrapper. There has also been much grooving down each side of the plate along the waist. To relieve the crown plate of these stresses some engines have been fitted with a row of flexible stays at the back end. The later boilers are now being made with the back plate flanged inwards, the final operation of riveting up this plate to the wrapper being done by hand. All new fire-boxes of the larger classes since January, 1904, have had wider water spaces, which have resulted in increased mileage and fewer repairs, particularly in the renewal of stays. The reduction of grate surface, caused by increasing the spaces, has not interfered with the steaming qualities of the engines.

In the ten-wheeled passenger and coal engines the original boilers had 239 tubes, 2 inches diameter, and the more recent

Fig.1

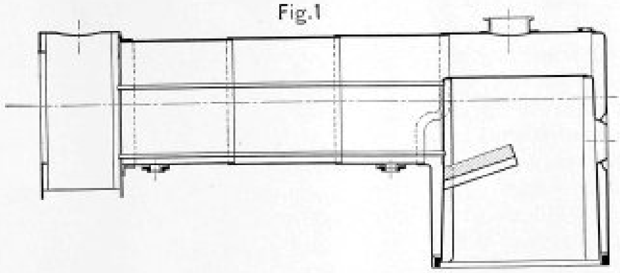


Fig.2

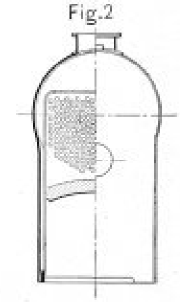


Fig.3

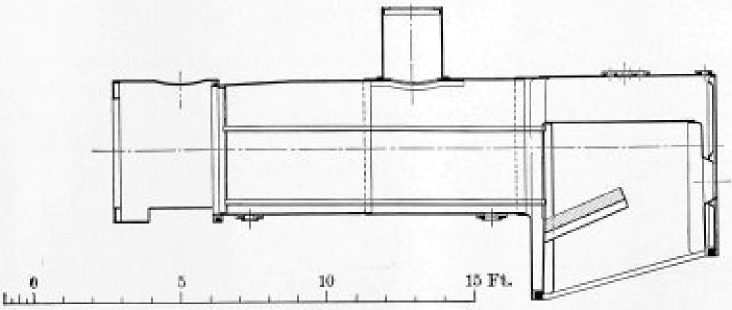


Fig.4

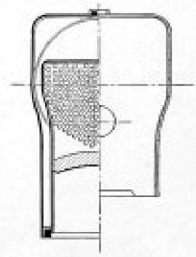


Fig.5

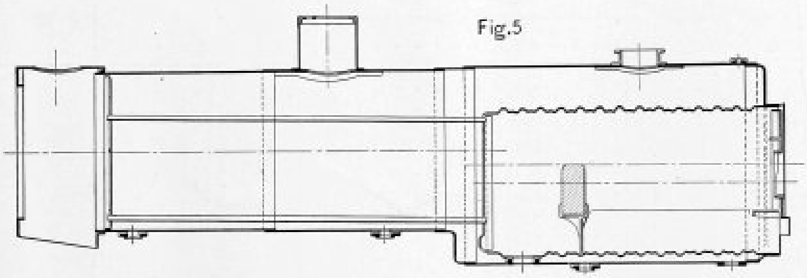


Fig.6

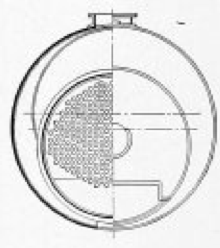


Fig.7

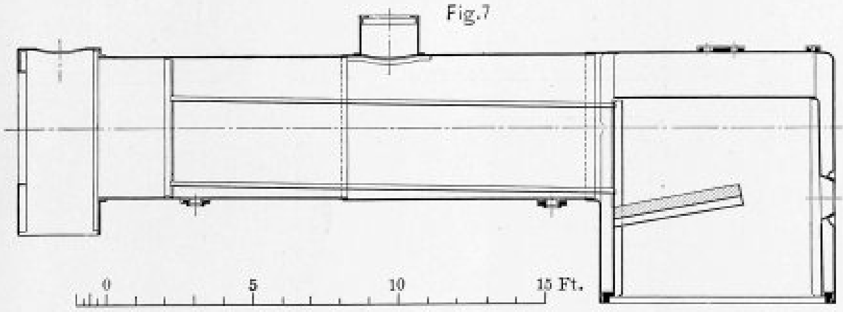


Fig.8

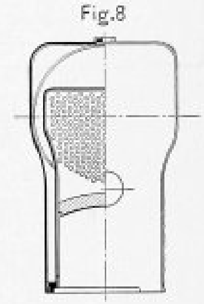


Fig.9

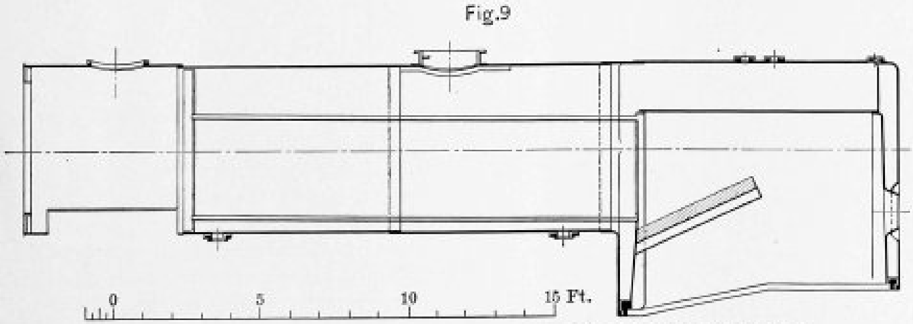
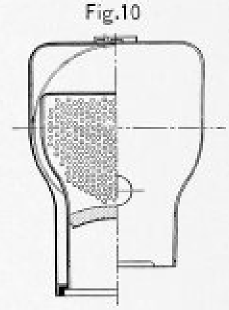


Fig.10



BOILERS FOR VARIOUS CLASSES OF ENGINES.

Figures.	Boiler.			Firebox Shell.		Copperbox.		Tubes.		Heating Surface.		Firegrate.
	Diam	Length.	Pressure.	Long.	Wide.	Long.	High.	Number.	Out. Dia.	Tubes.	Firebox.	
	Ft. In.	Ft. In.	Lbs.	Ft. In.	Ft. In.	Ft. In.	Ft. In.		Ins.	Super.	Feet.	Feet.
1, 2	4 2	10 7⅜	180	6 0	4 1	5 4¼	5 10	220	1¾	1108.73	107.68	18¼
3, 4	4 6	10 9⅜	180	6 4	4 7	5 6⅛	F 5 11¾ B 4 8¾	220	1¾	1086.	107.	18¾
5, 6	5 5½	12 9	180	Shell 6–8½ dia., Flue 9.6 long, dia. over corrugations 5–1½″.				280	2	1775.	125.	20
7, 8	4 10	15 0	180	8 1	4 1	7 5⅝	6 11½	225	2	1767.	161.	23
9, 10	5 8¼	15 0	180	9 6	4 1	8 7	F 7 0 B 6 1	295	2	2317.	190.	27

boilers with wide water spaces have only 225 tubes. In each top corner a group of tubes, fifteen in number, are reduced in diameter at the fire-box end to minimize the fracturing between the tube holes at these corners.

Copper and steel tubes are used, and their life, as in the case of boilers, is influenced by several circumstances, but over a period of eight years the average mileage works out as below:

	Miles.
Copper, first period (new)	110,000
Copper, second period (stretched)	80,000
Copper, third period (pieced)	50,000
Total	240,000

and subsequently 30 to 40 percent of those pieced are treated so again.

	Miles
Steel, first period (new)	70,000 to 80,000
Steel, second period (pieced)	30,000 to 40,000

BOILER PRESSURE.

Previous to year 1888 the boiler pressures did not exceed 140 pounds per square inch.

Previous to year 1899 the boiler pressures did not exceed 160 pounds per square inch.

Previous to year 1901 the boiler pressures did not exceed 175 pounds per square inch.

Present practice 180 pounds per square inch.

Copper fire-boxes run from 150,000 to 275,000 miles, and copper tube plates last three and three-fourths to seven years.

In all cases the life of the boiler is dependent upon the amount of patching and renewals of wrapper and mouthpiece plates, and restoring of tube, throat and barrel plates.

WEAR AND TEAR OF BOILERS.

This may be divided under two headings, namely, grooving and cracking, by reason of expansion and contraction; and pitting, brought about by deposits which are carried in solution and suspension in the water. The pitting at the smoke-box end is produced by chemical reactions going on in the mud which is deposited, and pitting round the stays and sides of wrapper plates, probably by chemical and electrical actions. The diagram, Fig. 11, shows the pitting and grooving of boilers and fire-boxes. So serious a few years ago was pitting in the bottoms of boiler barrels that the author decided to carry out a number of experiments with a view to eliminating the same. For example, cementing the bottoms of the barrels, using nickel steel plates, inserting steel and copper tubes mixed, and also suspending zinc blocks, but without any material improvement. Subsequently, he then selected a number of boilers, and lined the barrel bottoms with thin Low Moor iron sheeting, also old copper plates and lead sheeting. In three years the Low Moor iron sheeting was completely eaten through, and when examined resembled a riddle. The

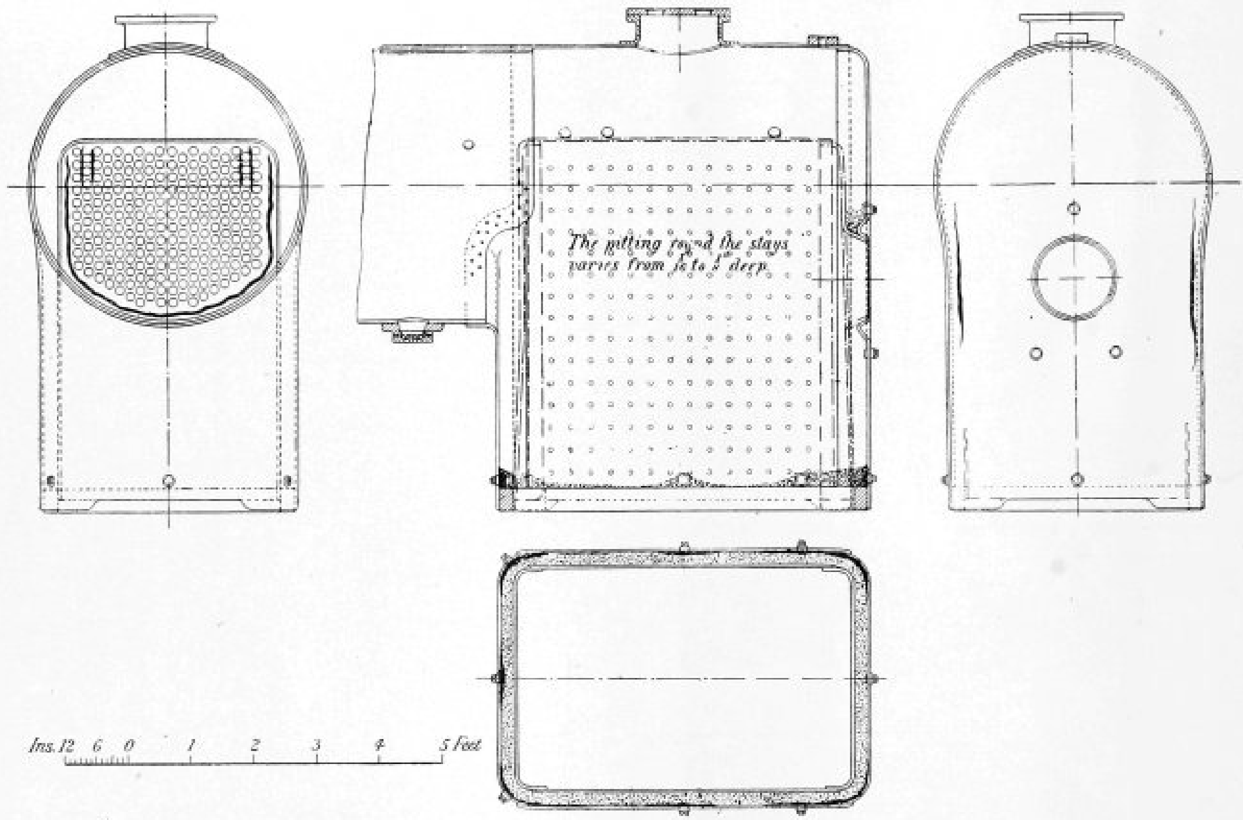


FIG. 11.—DIAGRAM SHOWING PITTING AND GROOVING OF BOILERS AND FIRE-BOXES.

LIFE OF BOILERS.

It is difficult to make just comparisons. This factor is influenced by many contingencies, such as pressure, constant employment, severity of use, etc. The following table may be of interest:

No. of Boilers Cut Up.	Average Age.	Maximum Age.	Miles.		Remarks.
			Average.	Maximum.	
336	18	38	485,480	1,207,191	For 10½ years ending December, 1897.
181	11¾	30¼	326,187	739,798	27 months ending May, 1902, and personally examined by the author
206	14¾	29¾	356,268	959,944	For 3 years ending December, 1908.

old copper plate, of course, remained intact, but the lead sheeting in twelve months' time had entirely disappeared. Before this disappearance, however, complaints were made to the author that the gage glasses were being coated with a white film, which obscured the water levels, and upon scraping sufficient from the inside of the gage glasses, in order to make a qualitative analysis, it was discovered to be lead carbonate. The author was induced to try lead on account of his knowledge of its acid-resisting properties; as traces of acid had been found in some of the water used, he did not anticipate that carbonic-acid gas would be generated in the bottoms of the boiler barrels to such an extent as to combine with the whole of the lead. From this discovery, a cycle of chemical reactions was formulated, and recognized as a reasonable explanation of the immense amount of pitting that goes on in locomotive and other boiler barrels. Table 1 gives the analysis of deposit from six different positions of the boiler barrel.

TABLE 1.

Substance.	Bottom of Barrel.			Side of Barrel.			Crown of Locomotive Fire-box.
	Smoke-box Plate.	Center Plate.	Fire-box Plate.	Smoke-box Plate.	Center Plate.	Fire-box Plate.	
	%	%	%	%	%	%	%
Silica	3.9	4.5	6.0	21.6	19.1	18.6	5.5
Oxides of iron and alumina	71.5	60.0	26.5	9.9	24.9	6.9	3.0
Sulphate of lime	2.1	5.8	48.8	1.9	4.8	2.2	68.0
Carbonate of lime	16.0	18.3	4.2	21.5	15.3	10.7	0.4
Lime, other than carbonate or sulphate, calculated as hydrate	.....	.....	.....	29.9	10.1	34.1	.....
Carbonate of magnesia	7.0	5.6	7.4	.....	.....	.....	9.0
Hydrate of magnesia	.....	5.7	7.1	12.5	26.0	21.1	14.0
Total	100.5	99.9	100.0	97.3	100.2	93.7	99.9

PRIMING.

To ascertain the real cause of priming, the author has carried out investigations which may be of interest.

Observations were made on several boilers of different designs, when it was found that design had little effect on priming, and that the real cause (provided that care was exercised in handling the engine, and the water level in boiler not exceeded) depended on the quality and quantity of water evaporated.

A chemical analysis of two waters experimented upon is given below:

	Grains Per Gallon No. 1.	Grains Per Gallon No. 2.
Carbonate of lime	4.9	3.8
Carbonate of magnesia	0.5	0.5
Sulphate of lime	3.7	3.2
Sulphate of magnesia	2.5	2.0
Oxides of iron and alumina	0.1	nil
Scale-forming matter	11.7	9.5
Sodium chloride	5.7	2.8
Total dissolved solids	28.0	16.0

It will be noticed that, so far as scale-forming matter is concerned, there is not a great variation in the two waters, but No. 1 caused priming much sooner than No. 2. The boiler fed by the former primed badly at the end of four days' work, whereas with the latter the engine ran six days before priming occurred. In both cases the daily evaporation was much the same. Seeing that priming occurred much sooner in the case of No. 1 than No. 2, and that the proportion of scale-forming matter was nearly the same in the two waters, the conclusions drawn were, that these scale-forming constituents did not produce priming.

The subject was next investigated in the light of salts other than scale-forming. These are best described as soda (or soluble salts), the predominating constituent being the sulphate. In order to ascertain to what extent these particular salts influenced priming, very accurate measurements were made of the water collected and evaporated. It was also analyzed for the quantity of solids carried into the boiler.

TABLE 2.—SHOWING THE GRADUAL CONCENTRATION OF SOLUBLE SALTS UP TO THE POINT OF PRIMING.

Engine No.	Class of Engine.	Day.	Grains of Soluble Salts per Gallon of Water in Boiler.	Remarks.
1402	10-wheel bogie passenger	1st	46	No priming.
1402	10-wheel bogie passenger	2d	117	No priming.
1402	10-wheel bogie passenger	3d	164	No priming.
1402	10-wheel bogie passenger	4th	210	No priming.
AFTER 4TH DAY BOILER WASHED OUT TO PREVENT PRIMING.				
281	Radial passenger tank	1st	127	No priming.
281	Radial passenger tank	2d	194	No priming.
281	Radial passenger tank	3d	269	Primed badly.
262	Radial passenger tank	1st	184	No priming.
262	Radial passenger tank	2d	266	Primed badly.
906	Radial passenger tank	1st	132	No priming.
906	Radial passenger tank	2d	230	Primed badly.

SMOKE-BOXES, BRICK ARCHES AND ASHPANS.

The success of an engine depends entirely upon the boiler, and the excellence of the latter turns on the subject of smoke-boxes, brick arches and ashpans.

The primary function of the smoke-box and its equipment is the production of draft, to economically burn the fuel at a proper rate, and at the same time to maintain satisfactory steaming when working under all conditions of service. These qualifications are dependent largely upon proper proportions; the location and diameter of blast-pipe nozzle; its relation to chimney and tubes and height and diameter of chimney. Blast pipes require to have an orifice sufficiently large to prevent back pressure in cylinders, and at the same time small enough to produce efficient draft. A proper disposition of the blast-pipe orifice, in its relation vertically to the chimney top, together with its right height from the boiler center line and a correctly proportioned chimney, will enable the orifice to be increased in diameter.

It must be remembered that an enormous amount of air enters the fire-box, and is immediately expanded six to eight times by rise of temperature, and upon arrival at the smoke-box and exit from the chimney, it is two or three times its original volume; and as the office of the smoke-box equipment is to deal effectually with this air, which is a variable quantity, a combination must be discovered for each class of engine which will produce the best all-round efficiency. With a view of arriving at some conclusions on this question, the author has from time to time carried out experiments on certain classes of engines, with the following results:

LONG VS. SHORT SMOKE-BOXES.

To ascertain the value of long and short smoke-boxes observations were taken on two radial passenger tank engines. Particulars are given in Table 3.

TABLE 3.—LONG v. SHORT SMOKE-BOXES.

Engine.	Length of Smoke-box.	Cubical Capacity of Smoke-box.	No. of Tubes.	Length Between Tube-plates.	Area Through Tubes.	Grate Area.	Air-space Through Grate.	Percent of Air-space.	Area Through Ashpan Door Opening.
No.		Cu. Ins.			Sq. Ins.	Sq. Ft.	Sq. Ins.		Sq. Ins.
33	32¼	100,190	220	11–0	388.7	18.75	865.25	32	274.95
34	46½	111,390	220	10–9¾	338.7	18.75	919.6	34	215.87

Both engines were equipped with identically the same blast pipe, chimney and hood, but the smoke-box of one had a capacity 11 percent greater than the other. The smoke-box arrangements of the two engines are shown by the following diagram, Fig. 12.

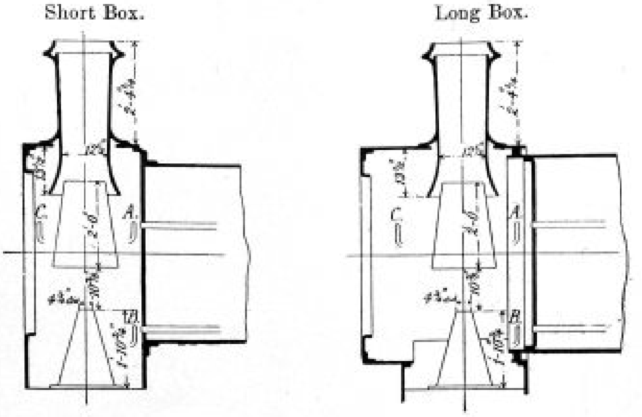


FIG. 12.—VACUUM BOX TESTS.

TABLE 4.

Test.	Between Manchester and Bolton.				
	Vacuum in Inches Water Gage.			Boiler Pressure, Lbs. per Square Inch.	Cut-off, Percent of Stroke.
Type of Smoke-box.	Top Row of Tubes. A	Bottom Row of Tubes. B	In Front of Blast Pipe. C		
	Inches.	Inches.	Inches.		
Short type.......	3	3	3	157	39.2
Long type.......	3	3	4	175	39.2
	Between Bolton and Entwistle.				
Short type.......	3	3	3	157	39.2
Long type.......	4.4	4.4	5.2	174	51.7

Vacuum readings were observed at points *A, B, C,* through pipes projecting into the smoke-box to the vertical center line of the engine; the outer end of each pipe was connected by rubber tubing with one leg of a manometer, or "U"-shaped glass tube, partially filled with colored water, and Table 4 gives a summary of the results.

In perusing this table it will be noticed that the vacua are even all over the tube plate, indicating that the position of blast nozzle, hood and chimney appeared to be about right. With the extended smoke-box a higher vacuum is recorded at *C* than at *A* and *B,* which tends to prove that the long box serves as a reservoir, thus assisting the maintenance of draft between each exhaust, and so modifying the intermittent character of the blast. This is verified by the action in the glass tubes. With the extended smoke-box the water remains quite steady, and only moves when the steam discharge up the chimney is altered; whereas, with the short box the water is in a constant state of agitation, rising and falling with each exhaust. The vacuum in both smoke-boxes was about normal for the cut-offs of 39 and 51 percent, respectively, but steam pressure was better maintained in the extended smoke-box engine.

EXPERIMENTS TO DETERMINE THE HEIGHTS AND LENGTHS OF HOOD AND BLAST PIPE IN RELATION TO TUBES.

A series of experiments were conducted on one of the radial passenger tank engines with extended smoke-box. Five different arrangements (Fig. 13) were tested as follows:

A. Blast pipe 1 foot 2¼ inches below horizontal center line of boiler; hood, 1 foot 11½ inches long.

B. Blast pipe 1 foot 2¼ inches below horizontal center line of boiler; hood, 1 foot 5½ inches long.

C. Blast pipe 1 foot 2¼ inches below horizontal center line of boiler; without hood.

D. Blast pipe 2¼ inches below horizontal center line of boiler; without hood.

E. Blast pipe 9¼ inches below horizontal center line of boiler; hood, 1 foot 5½ inches long.

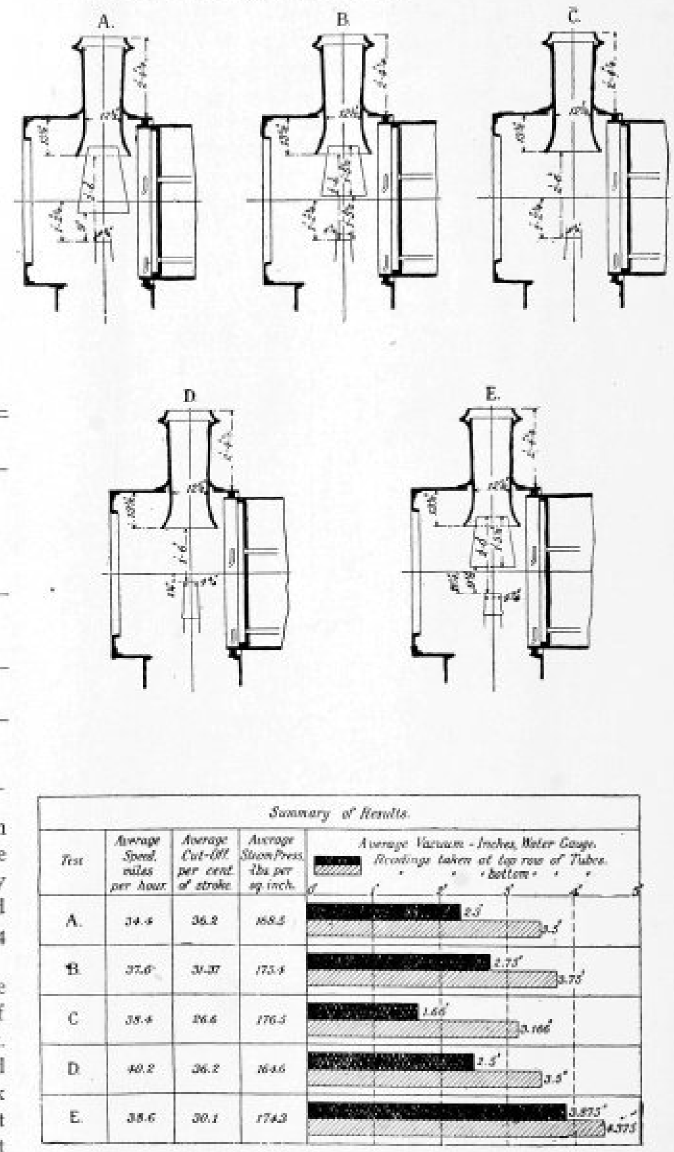


FIG. 13.—EXPERIMENTS TO DETERMINE THE HEIGHTS AND LENGTHS OF HOOD AND BLAST PIPE.

On the first four tests the loads were the same, namely, 160 tons behind the draw-bar, but on test *E* the train hauled was 200 tons. The same chimney was used on all trials, namely, 12½ inches diameter choke, tapered, and increasing 1.4 inches per foot towards the top; length, 2 feet 4¼ inches. The blast nozzle was 4¾ inches diameter in all cases. Diagrams, letters *A* to *E,* show the different arrangements tried, and the table underneath gives the summary of results. The best conditions were obtained from test *E* arrangement, as regards the highest vacuum and least variation in the intensity of draft at the top and bottom row of tubes. Test *C* was also very satisfactory, considering the low vacuum maintained. This, however, is accounted for by the fact of the weather being calm on that occasion, enabling the engine to be operated at an earlier cut-off and with less demand on the boiler.

POSITION OF CENTER LINE OF BLAST PIPE IN RESPECT TO SMOKE-BOX TUBE PLATE.

To ascertain the best position of the blast pipe in its relation to the tube plate a number of experiments were carried out. The diagram (Fig. 14) shows the arrangement of the apparatus, and the table underneath gives the results of the tests.

The tests were made under similar conditions in regard to route and load. The reversing lever was moved at the same places on the route, and vacuum readings taken accordingly. The weather was similar on all runs, and the same driver and fireman operated the engine. The table shows that No. 2 test

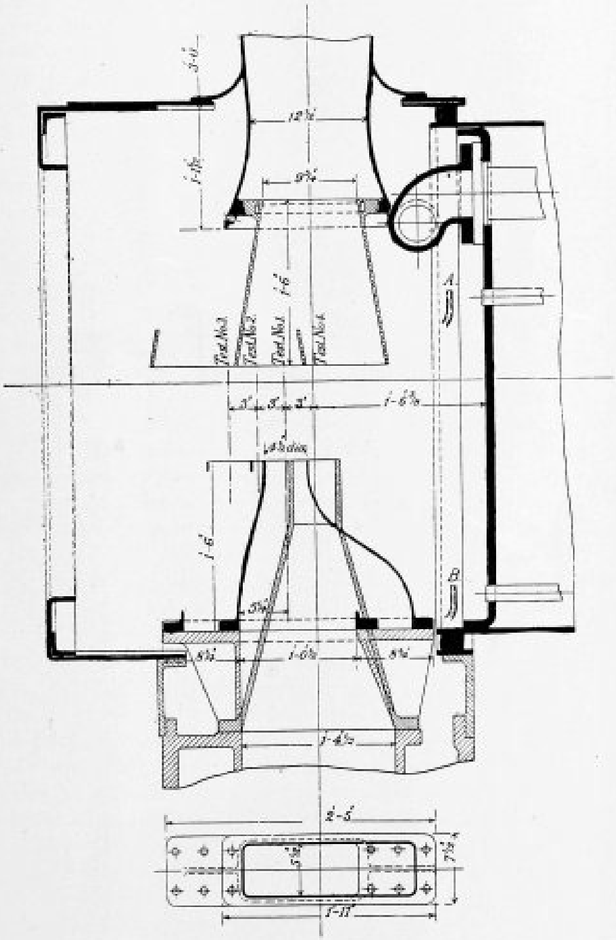


Table of Results of Tests.					
Position.		Test No. 1.	Test No. 2.	Test No. 3.	Test No. 4.
Vacuum Inches Water Gauge.	At top row of Tubes A.	6.5	6.3	5.6	6.9
	At bottom row of Tubes B.	5.0	6.8	6.0	5.9
Boiler Pressure.		lbs. 177.60	lbs. 181.50	lbs. 176.9	lbs. 180
Maximum Temperature.		880°F	860°F	860°F	850°F
Minimum Temperature.		600°F	620°F	580°F	560°F
Mean Temperature.		750°F	796°F	745°F	754°F

FIG. 14.—EXPERIMENTS ON THE POSITION OF BLAST PIPES.

gives the best results as regards even draft, so it may be concluded that the blast pipe placed nearly midway between the door and tube plate commends itself. The vacuum readings and smoke-box temperatures seem to be high, but this must be expected, owing to the class of work. Taking the four results, the moving of the blast pipe further from the tube plate has no very serious effect on the steaming of the engine; and if convenience is a consideration in designing smoke-box details then the blast pipe may be removed without serious consequences.

RESULTS OF EXPERIMENTS ON FOUR-CYLINDER PASSENGER ENGINE.

This engine, when first put into service, had a 5-inch diameter blast nozzle standing 8 inches below the center line of boiler. The chimney was only 12½ inches diameter at the choke, and had an extension in the smoke-box of 15 inches. This extension carried a hood 1 foot 6 inches long. Further particulars are given below:

Length of smoke-box..............	68 inches.
Capacity of smoke-box............	249,000 cubic inches.
Number of tubes..................	235
Length of tubes..................	15 feet.
Area through tubes...............	564.0 square ins.
Grate area.......................	27.0 square ft.
Air space through grate..........	9.47 square ft.
Percentage of air space..........	35
Area through ashpan, door open....	394.0 square ins.
Minimum area of ashpan opening..	63.0 square ins.

On the first trial it was evident that the nozzle was too small, and it was decided to open it out to 5½ inches. This step, however, at first had a detrimental effect on the steaming, until the author tried a chimney of a different design. He retained the same pattern, but cut down the extension portion, to penetrate into the smoke-box 2 inches only, which increased the choke to 13½ inches diameter. He also belled out the entrance to 18 inches diameter. It was apparent at once that this form of chimney, although not quite satisfactory, improved the steaming; therefore further investigations were conducted on the best height of nozzle, and eventually it was found to be about 4 inches below center line of boiler. During these experiments complaints were frequent that the fire burnt dead at the back end of the fire-box, and conclusions were drawn that this was due to the restricted air-space opening in the ashpan, where it is narrowed down in depth to clear the trailing axle. The author next decided to give additional air supply to the back end of grate. He therefore connected the front and back portions of the ashpan by an air duct shown on the following page. This addition increased the air-supply opening over 300 percent, and has proved very beneficial in promoting combustion.

A further experiment has recently been made with a larger blast pipe and chimney. The blast pipe is cast with a bridge, so that the exhaust from the inside and outside cylinders is led away independently, and does not meet until near the top of the nozzle. The nozzle is 6 inches diameter, and the chimney choke 16 inches, the same design of chimney with short extension being adhered to. At first this combination was not successful, but after several trials with varied heights of blast pipes a position was discovered (viz.: 6 inches below center line of boiler) which produced an excellent steaming engine.

These experiments go to prove the importance of ascertaining the correct positions and proportions of blast pipes and chimneys; for here is a case of an engine which would not steam with a 5½-inch blast pipe, but which eventually, after numerous experiments, steamed well with a 6-inch nozzle. Attempts have been made in America to standardize front ends with some amount of success; but it appears to the author that each new design of locomotive demands some experimental work, in order to arrive at the best steaming position of blast pipe, diameter of chimney, etc.

SMOKE-BOX DOORS.

These are much larger than ten years ago. They cannot be kept perfectly tight by the single cross-bar and central bolt arrangement, and a number of dogs pitched equally round the periphery of the door is essential. The wear and tear of smoke-boxes has increased of late years, particularly that class with the sides fastened to the main frames of the engine. The round smoke-box, supported on a cast iron saddle, has much to recommend it. The author has adopted this design on several tank engines and also on the four-cylinder passenger engine. This latter smoke-box has been clothed with asbestos and a thin clothing sheet, for the purpose of reducing cost of maintenance.

BRICK ARCHES.

All engines are fitted with brick arches. These extend from the tube plate to about half the length of the fire-box. The rake of the arch is governed to some extent by the position of the fire-hole above the grate. When this distance is small and the fire-box long it is necessary to incline the arch, so that there is no chance of throwing the fuel upon it. With the fire-boxes which have horizontal grates the arch slopes upwards, pointing to the top side of the fire-hole. In the four-cylinder engine the slope points to the top corner of the back plate. The function of the arch is to assist combustion by maintaining a high temperature, and to direct the gases round the fire-box, especially so that they impinge against the top and back plates. The fire-hole deflector is used to prevent the air passing direct to the tubes.

ASHPANS.

All ashpans are made of ample dimensions, so that the accumulated ashes do not hinder air supply. The damper doors open as wide as possible to allow a maximum air supply and for convenience of raking. The bottom is made to retain

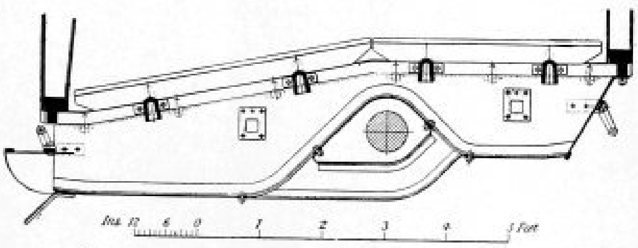


FIG. 15.—ASH-PAN AND FIRE-BAR ARRANGEMENT FOR A FOUR-CYLINDER PASSENGER ENGINE.

water for quenching the ashes, a small pipe being connected to the injector feed pipe and led to the ashpan for that purpose. The damper door handles are fixed on the fireman's side of the engine, and have a screw arrangement for adjusting the amount of air and for closing the door practically air-tight.

There is ample room for discussion and experiment on the subject just mentioned. It is remarkable what a small amount of information is available.

THE HARLAND & WOLFF BOILER SHOP.

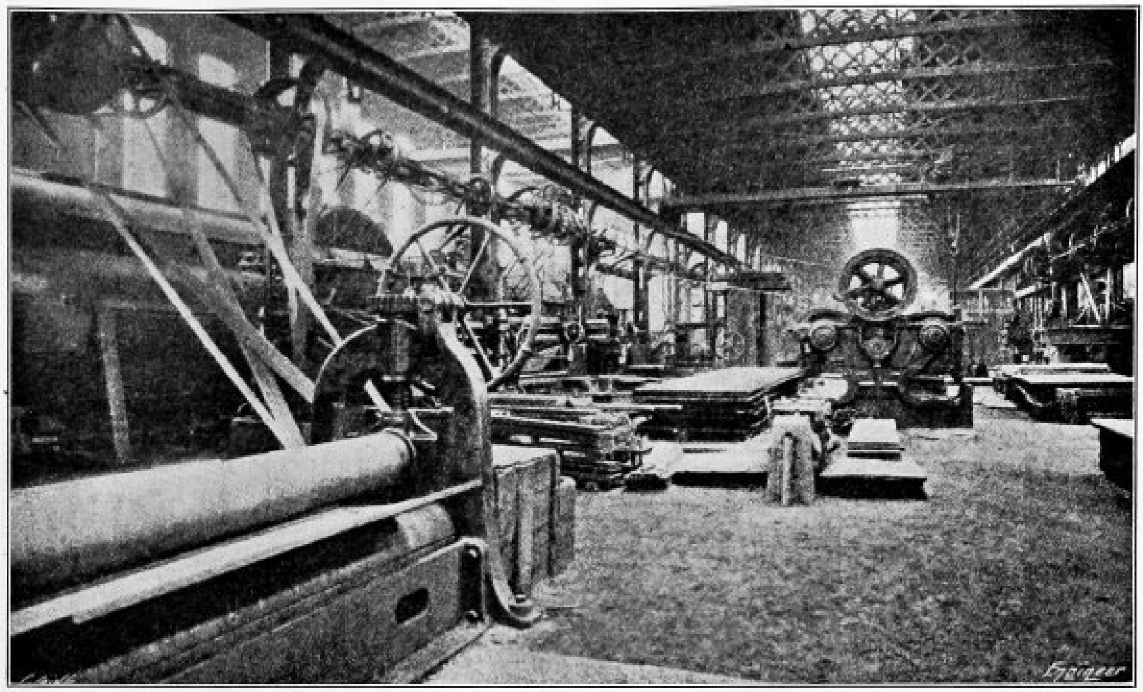
One of the finest shipbuilding works in the world is that of Harland & Wolff, of Belfast, Ireland. This plant has a yearly capacity of 100,000 tons of shipping and 100,000 indicated horsepower. It was established fifty years ago by E. J. Harland, the works covering about 3¾ acres and employing forty-four men. To-day the plant covers eighty acres and gives employment to over 12,000 men. In spite of the fact that every ounce of material required in the construction of ships has to be imported, and that the country in which the plant is located produces no coal, iron or copper, and, furthermore, has no steel works to manufacture plate or bars, even if the iron and coal were there, yet the present company is engaged in building the largest ships in the world, the *Olympic* and *Titanic* of 45,000 tons each for the White Star Line.

From a very complete description of this plant, recently published in *The Engineer*, we have abstracted the following description of the boiler shop, which is certainly worthy of consideration by every up-to-date boiler maker in the world.

One of the most important shops in the whole works is the boiler shop, four views of which are shown herewith. A great variety of work is carried out in it in addition to actual boiler making. As an example, we may quote the huge funnels for liners, which, now-a-days, attain such enormous dimensions. Perhaps our best plan, in order to give some sort of an idea as to the equipment of this fine shop, will be to mention a few of the tools which may be noticed in a walk through the shop. The shop is divided into two main parts, which are at right angles to one another. On entering at the end of the shop opposite to the gate house, one's eye is caught at once by a fine right angle plate edge planing machine by Hetheringtons, which will take in plates up to 36 feet long. Two 20-horsepower 440-volt Vickers' motors are geared to this machine. They are constructed to run at speeds varying from 300 to 900 revolutions per minute, and are governed by an automatic controlling gear, which reverses the direction of the tool when it comes to the end of the cut. Close by is a large vertical boring and surfacing machine, by Embleton & Co., of Leeds. This also has its own motor. Then there is a tube-plate cutting machine, by Shanks, and a smaller plate-edge planer, by Bucktons. This also is automatic in its action, and, like the other, has a variation in speed of from 300 to 900 revolutions per minute in its motor, which is of 10 horsepower, and is made by Vickers, Sons & Maxim, Ltd.

After passing by a shearing and punching machine, some small plate rolls, a marine boiler-tube plate drilling machine, and some other smaller drills, we come to a series of hydraulic machines, which are noteworthy. In the first place, there are three fixed hydraulic riveting machines, which can take in work about 5 feet, 9 feet and 15 feet deep, respectively. The first of these is furnished with its own electrically-driven hydraulic pump and accumulator, but the others are worked off the main system of pressure pipes, which are laid throughout the works. Another large and interesting tool is an upright hydraulic plate-bending machine, which will take in plates up to 12 feet wide. This machine, which was made by Fielding & Platt, of Gloucester, works on the toggle principle, rollers being made to run up inclined planes by means of hydraulic cylinders. As a contrast to this there is, not far away, a large set of horizontal bending rolls, made by Shanks, and driven by a 33-horsepower motor running at 270 revolutions per minute. This can take in work up to 10 feet 6 inches wide. Other tools in this part of the shop include a set of three radial drills, by Shanks, each driven by its own motor; two punching and shearing machines, by Craig and Donald, both electrically driven, the motor in the case of one being mounted on a spring carriage, and of the other rigidly; some smaller plate-bending rolls driven through gearing by a 12-horsepower motor running at 860 revolutions per minute; some small flattening rolls, also driven electrically through gearing by a 7-horsepower motor, the speed of which is 590 revolutions per minute; some further drills, etc.

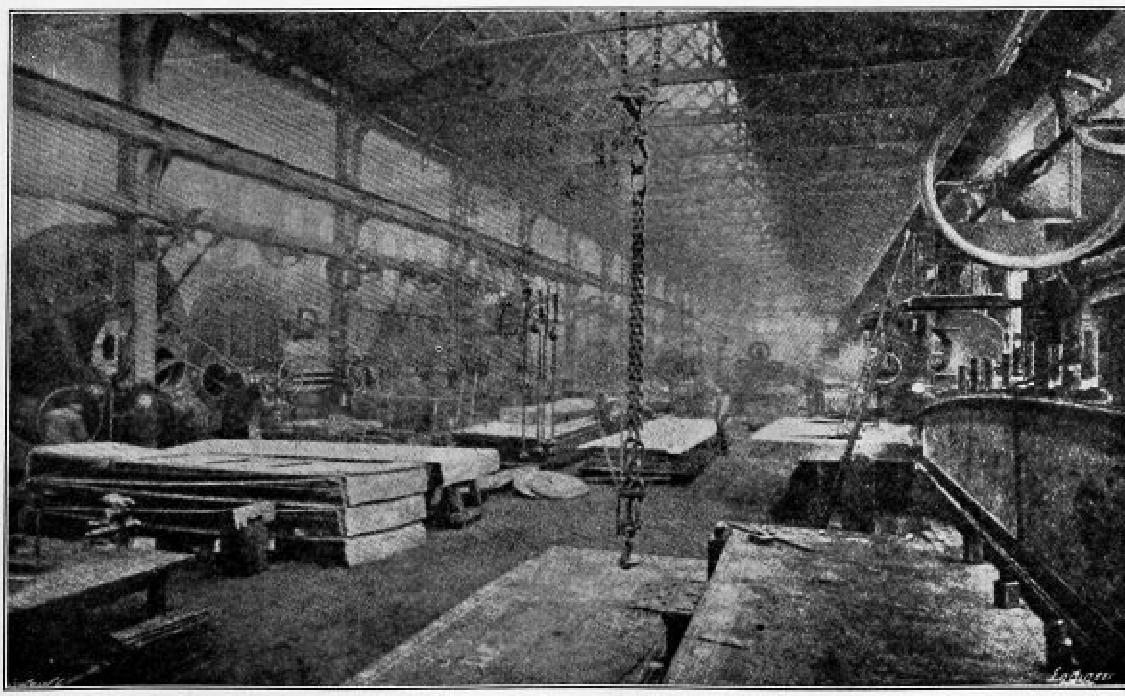
The two main bays of this portion of the shop are served by six electric cranes—two in one bay, each by Cravens, and each of 5 tons capacity, and four in the other bay, these being of varying powers. There are two large plate heating furnaces in one of the smaller bays. These have their own separate chimney, and are provided with steam forced draft. There is also a number of rivet furnaces. This bay is provided with a 5-ton overhead crane. In the small bay there are seventeen smiths' hearths, the blast for which is provided by a motor-driven fan. Here, too, is a Nasmyth-type power hammer, pneumatically worked, the makers of this being Davis & Primrose, of Leith. The buildings have cast iron uprights and



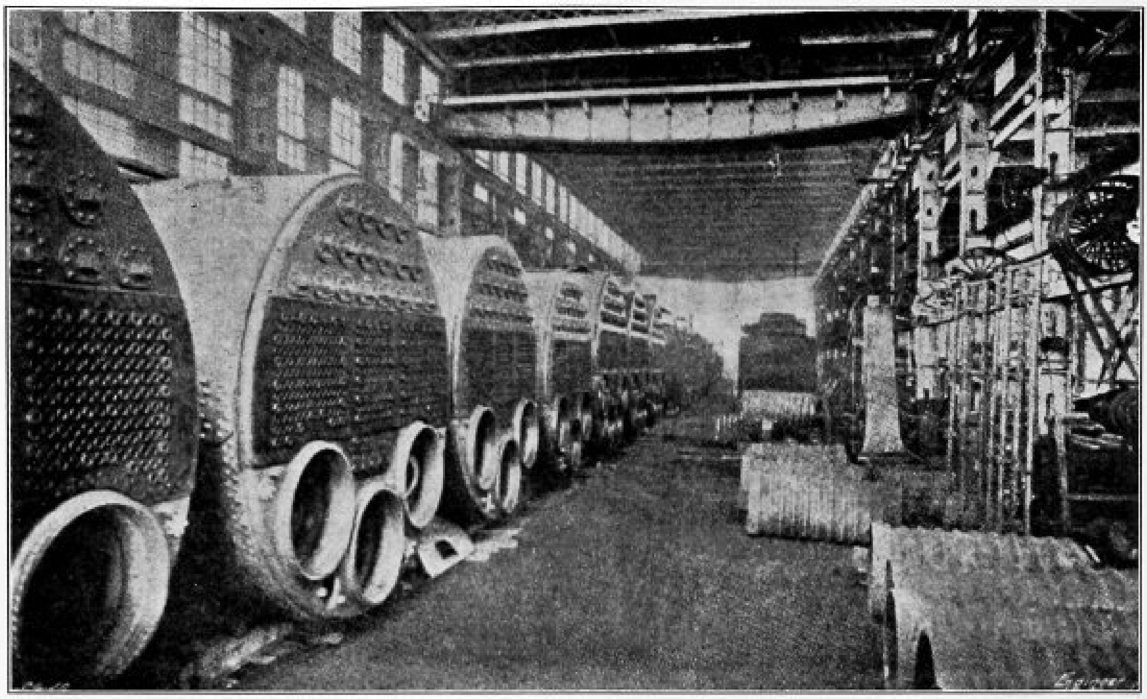
VIEW SHOWING VERTICAL AND HORIZONTAL ROLLS.

light section principals, the sides and roofs, where there are no windows or glazing, being of corrugated iron. The shops are exceedingly well lit. Arc lamps provide light for night working. Full gage rails run into the shop from the yard and roadway.

At right angles to that part of the boiler shop which we have just been describing is the other portion of the shop. This consists of two long bays running side by side. At one end there are six smiths' hearths, and near by are two electrically-driven punching and shearing machines, by Craig & Donald. Each has its own radial jib crane. Next comes an automatic electrically-driven plate edge planing machine, by the same makers, the motor for which is of 10 horsepower. It would be wearisome to enumerate the whole list of excellent tools and machines which find a place in this shop, but we may say briefly that among a number of others there are

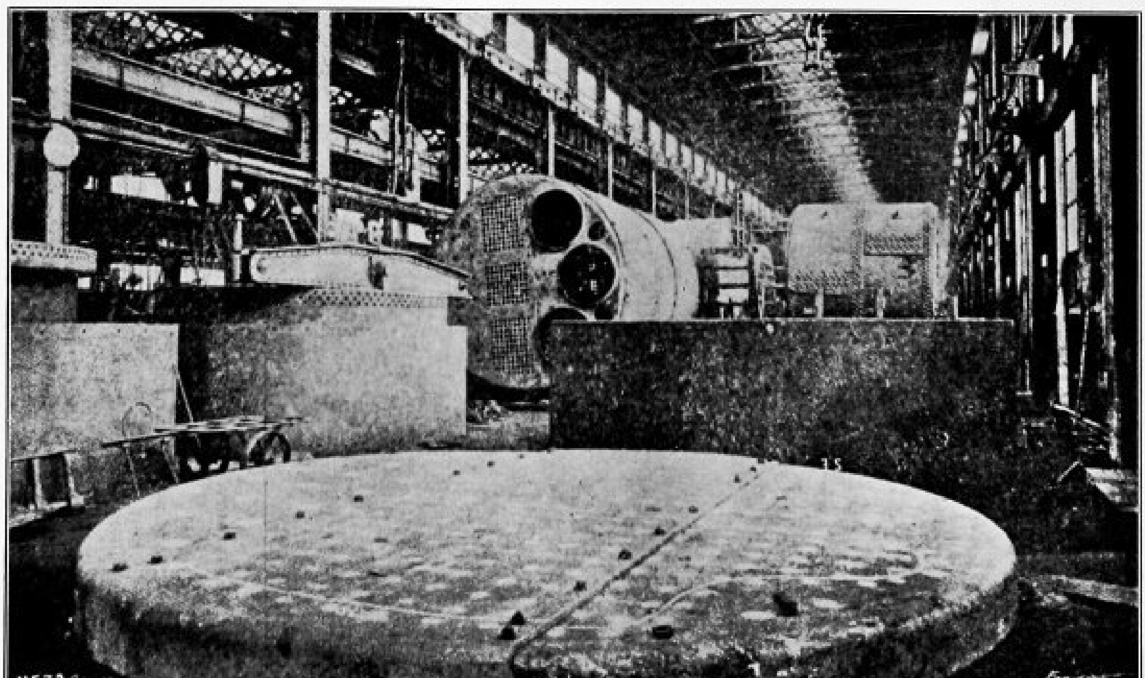


THE BOILER SHOP FROM THE SOUTH END.



VIEW SHOWING RANGE OF BOILERS FOR A LARGE ATLANTIC LINER.

an electrically-driven horizontal air compressor; a special boiler drill, with four adjustable uprights, by Smith, Beacock & Tannett; numerous radial drilling machines on the uprights of the building; a large pillar drilling machine; an hydraulic riveter; an hydraulic and other punching and shearing machines; screwing and other lathes; a horizontal revolving head planing machine; a 3/16-inch plate-shearing machine to take in work up to 5 feet wide; and a circular cold saw driven by a 2-horsepower motor running at 700 revolutions per minute. The building is similar to that just described, saving that it has a "Belfast" roof. There is a 10-ton overhead traveling crane in one bay, and three cranes of different capacities in the other bay. The illustrations give some idea of the immense amount of work done in this shop.



BOILERS UNDER CONSTRUCTION.

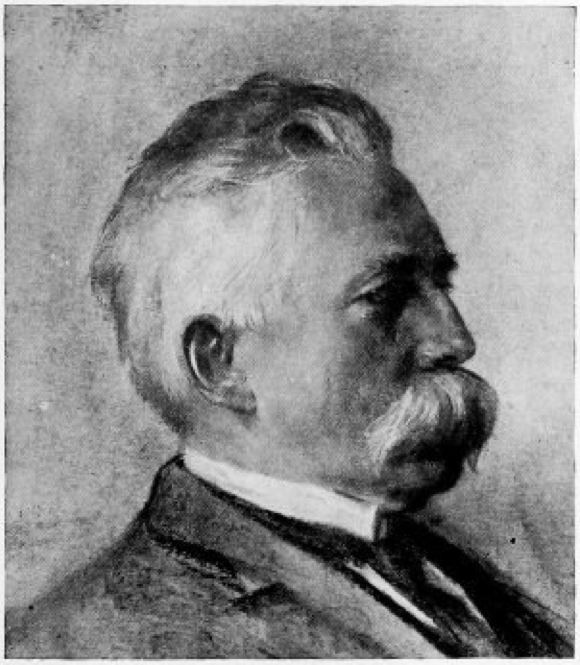
AMERICAN BOILER MANUFACTURERS' ASSOCIATION.

Proceedings of the Twenty-First Annual Convention.

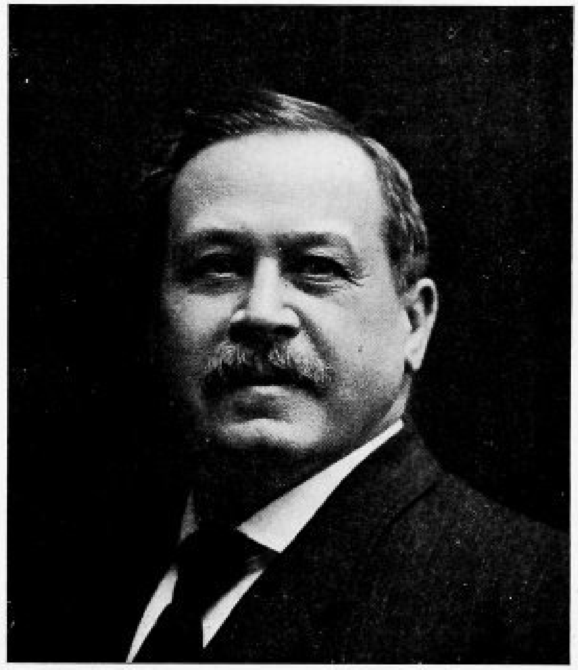
The twenty-first annual convention of the American Boiler Manufacturers' Association, held at the Hotel Ponchartrain, Detroit, Mich., was opened on Tuesday morning, Aug. 10, by the president, Col. E. D. Meier, of New York. The first speaker was Hon. Philip Breitmeyer, Mayor of Detroit, who extended a kindly greeting on behalf of the city, to which Col. Meier responded happily, recounting some of the earlier history of Detroit, and especially expressing gratification at the attendance of the Canadian manufacturers.

Mr. J. C. McCabe, chief boiler inspector, Detroit, addressed the convention, stating that at the present time there are before the City Council of Detroit two proposed ordinances covering boiler inspection widely different in their character. He had recommended for adoption rules patterned after the Massachusetts rules, believing that their adoption in toto would be desirable and advisable. At the last meeting of the Michigan Legislature a bill was passed providing for inspection of all boilers on inland lakes. In view of the fact that no legislation now exists in that State covering land boilers it is highly important that a proper ordinance be passed by the city of Detroit, in the expectation that it may serve as a model for State legislation at the next meeting of the Legislature. There are in the State of Michigan some 9,000 steam boilers, a great many of which are of antiquated type, and there have been a great many disastrous explosions, the record of the State being perhaps the worst of any in the Union. In sawmills, etc., about the State there are many cheaply constructed boilers, and hundreds of boilers of inferior grade are constantly being shipped into the State. At present there is no authorized standard, nor is there any inspection other than that made by the insurance companies. The records show that less than one-half of the boilers are inspected at all.

Mr. McCabe later presented a written communication requesting the A. B. M. A. to endorse the movement in support of the adoption by Detroit of a code of rules following the Massachusetts rules, and by unanimous vote the association adopted such a resolution at a later session of the convention. It is expected that shortly there will be appointed by the Governor of Michigan a commission to report on the advisability of State-wide inspection laws.



COL. E. D. MEIER, PRESIDENT.
(Portrait from "Steam.")



CAPT. T. M. REES, FIRST VICE-PRESIDENT.

Report of Committee on Topical Questions.

Your committee present for your consideration the following topical questions, viz.:

1. Why is it required to use heavier heads in boilers for Western rivers than on the Atlantic coast?

2. What is the best method of keeping water in circulation in corrugated furnace boilers?

3. In return-tubular boilers made in more than one sheet, which is the best practice, to make the lower half in one sheet or to have a girth seam, same being clear of the direct action of the fire?

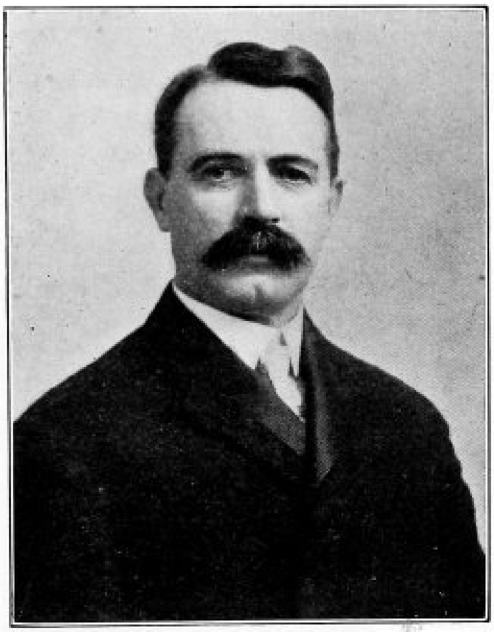
The latter subject was brought up at our last Cleveland meeting, but we think it should be discussed again, as we have since taken in a number of new members to whom it may be of interest, and who may give us some valuable information.

To open the subject, some years ago we built a battery of return-tubular boilers, 60 inches in diameter. After running several years the furnace of one of the boilers came down from the effects of scale or oil. In my opinion had the boiler been built with the bottom half in one sheet an explosion would have occurred, the only thing preventing this being the girth seam. The largest bulge was in the front sheet, the seam being intact, while the second bulge started just back of the seam; the seam held, but opened enough to let water out over fire. I would like to hear from the members along this line.

As opening up an interesting matter for discussion your committee invite attention to the matter covered by a letter received, from which the following is an extract:

"We have had some interesting experiences in the proper heating of boiler rivets with oil. We use the Tate-Jones oil rivet heating furnace and Chambersburg riveter and Champion rivets, all good goods, but after having been very successful for years making tight rivets, all at once we seem, from some cause, to have lots of leaking rivets, causing lots of trouble. We took it up with the Tate, Chambersburg and Champion people. Mr. Champion very kindly sent us a book he had had compiled by several boiler men, being a special prize letter on the subject, and after reading up thoroughly and testing several pieces of work we became convinced that the trouble was too high air pressure, the bridge wall in the oil furnace having burned down so the air blew directly on the rivets, and, overheating, caused a scale, so it was almost impossible to get tight rivets.

"Our foreman had decided he must go back to heating with coke; but after reducing the pressure to, say, 8 to 10 pounds, and replacing the bridge wall in the Tate oil furnace, and



J. D. FARASEY, SECRETARY.

heating the rivets only to a cherry red, not white heat, we got good results, and recently riveted two 84-inch by 20-foot high-pressure return-tubular boilers without a leaky rivet at 260 pounds. We feel satisfied that more than half the trouble with machine-driven rivets is caused by heating the rivets too hot, causing scale to form on them."

From another correspondent your committee has received the following:

"Under the head of topical questions, to be discussed at our next meeting, I would suggest the following question:

"Has the introduction of gas engines, gasoline engines, water-power plants and central electric power plants reduced the number of steam boilers in service, and has the demand for steam boilers decreased on this account?"

J. DON SMITH, Chairman.

Relative Thickness of Heads in Boilers on the Western Rivers and the Atlantic Coast.

Capt. Rees, of Pittsburg, stated that the ½-inch heads formerly employed on 40-inch boilers had now been replaced by ⅝-inch, which is the government requirement on Western rivers, and nothing less will withstand pressures of 200 to 215 pounds of steam. Capt. Rees said he was a firm believer in the United States laws governing tensile strength and thickness of boilers. The old ½-inch heads had to be patched frequently, which is not true of the ⅝-inch now used. The boilers in use are mainly externally-fired two-flue, four-flue, five-flue, six-flue and seven-flue, the seven-flue being the type preferred by Capt. Rees for his own use. Capt. Brobst, Bay City, Mich., asked if trouble was not experienced with unequal expansion of shells and tubes? Capt. Rees replied that since the introduction of machine flanging he had not noticed any difficulty in his practice. Mr. Mackinnon said he had not had experience on the Western rivers, but thought ½ inch or 9/16 inch used in connection with shells of .36 or .38 inch ought to be ample for protection. Col. Meier called attention to the fact that those not familiar with Western river practice would no doubt find difficulty in realizing the extremely hard service to which boilers are subjected there under the high steam pressures that obtain. The boilers are worked as hard as those on torpedo boats, good, free-burning coal being consumed at the rate of 50 pounds per square foot of grate surface per hour with forced draft.

Circulation in Corrugated Furnace Boilers.

Mr. H. J. Hartley, of Cramp's shipyard, Philadelphia, said there were many ways of accomplishing this end; one being to place a jet of steam in the bottom of the boiler. There is also an instrument called a hydrokineter, that is something like an injector, and used as the boilers are being fired up; as soon as the temperature becomes uniform in the top and bottom of the boiler the use of this is discontinued for the time. It is most important to get the circulation properly started at the outset of raising steam, and it can then be more easily maintained afterwards. If a reasonably uniform circulation is not maintained there is bound to be unequal expansion of the shell and liability to leakage as a result. This leakage is more apt to occur at the curvilinear seams. Few Scotch boilers are constructed with such seams; and with boilers having such seams double riveting or triple riveting generally cures the trouble complained of as to leakage.

Mr. F. B. Slocum, of the Continental Iron Works, Brooklyn, said that with a Scotch boiler of the type made by them excellent results had been gotten as to circulation by the employment of a brick baffle arch placed at the back end of the furnace just before you come into the combustion chamber, the object being to baffle the gases, compelling them to pass down and strike the bottom of the furnace before they pass out into the combustion chamber; also to contract the opening of the furnace mouth at the back end of the furnace. Experiments conducted, not only on the Scotch but on other types with the use of the baffle described and also without its use, showed conclusively its good qualities in distributing the gases and preventing excessive ash deposits, that insulate the boiler and prevent the heat acting effectively. In some large installations the circulation is started with a pump that pumps into the bottom of the boiler, but this is not necessary, in the opinion of the speaker, where the baffle arches described are used.

Mr. John J. Main, of Toronto, Ont., described a device consisting of a shaft entering into the front end of the boiler, running through to the back end with miter gears on the shafting, and a vertical shaft from that extended downwards near the bottom of the boiler, with a small propeller wheel, about 10 inches in diameter, placed on same, and a small hand crank on the shaft on the front end, to be operated by the fireman during the early stages of raising steam. These propellers agitate the water and create a circulation before steam is raised. Being asked how he fed the boilers, Mr. Main replied that they were fed at the top, a pipe being turned down into the bottom of the boiler, then a nozzle turned up; the pipe is run down past the combustion chamber along the bottom and then turned up.

Mr. Ryan said he had experimented with the feed, and used two feed pipes instead of one. On the lakes trouble is had with pitting of the bottoms of boilers below the fire line. The use of the two feed pipes, constructed as described by the speaker, had cured this difficulty. Capt. Rees said he had been working with baffle plates and was a great believer in them, but so far had not been able to find a metal baffle that would stand high heats; but had heard of a new material which was represented to give excellent results in that way, and more than equal fire-clay in ability to withstand high heat. He had obtained the circulation desired by the use of a blow-pipe going into the boiler first into the steam space between the flues.

Col. Meier called the attention of Mr. Slocum to the fact that if working with Eastern coal he was under entirely different conditions than confront the Western river men, whose coal contains far more sulphur, and much of it contains what is called white sulphur by the engineers, a sulphate of lime that makes not a little complication when the coal contains iron pyrites; when that gets hot it will flux with the firebrick; that is especially the case on the Mississippi River.

Mr. Schaaf asked if he properly understood Mr. Ryan that he had not gotten any scale in his boilers in three years' use of the device described by him? Mr. Ryan replied that it made the scale soft, so that it could easily be blown out. The water is passed through purifiers first, which are nothing but a common wooden box with three or four departments, into which steam is introduced and the water forced through; the boiler absolutely shines inside.

Rivet Heating.

Mr. C. J. Wangler, St. Louis, reported having had trouble with leaking rivets using oil furnaces, and had gone back to coal. Though it may be possible that the oil furnace may be so regulated as not to give trouble, yet with the class of men obtainable in many instances the regulating of the heat is more difficult to secure, and coal is preferable on this account.

Mr. Wangler reported that a certain scale was formed by this process in practice that gets into the die and cuts it all to pieces; it seems to stay right on the rivet, and does not seem to work out. The scale also gets into the crevice between rivet and sheet and prevents tight contact.

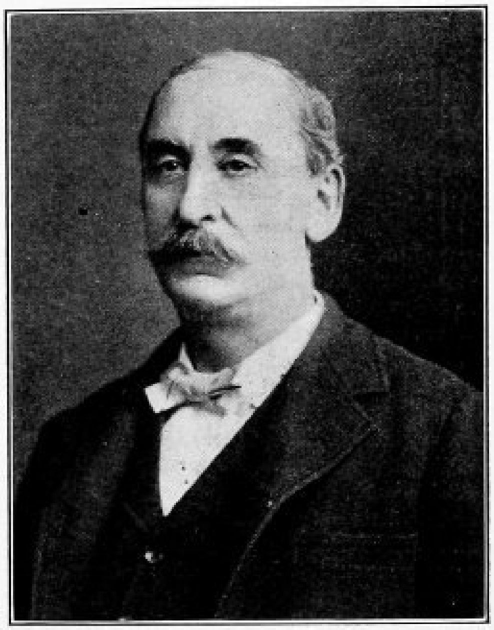
Mr. Hartley commented that scale might be produced on rivets from many causes, and often occurs by having too many rivets in the furnace at one time. Scale generally forms when the furnace is idle, waiting for rivets to be called for. If the temperature falls in the furnace scale forms immediately. For hydraulic machine work, rivets should not be heated above a good, bright red heat. He mentioned the electrical heating process under water, and believed this to be expensive and dangerous, although producing apparently excellent results otherwise. He said that too much attention cannot be paid to the mode of heating and also to the removing of the burr off the edge of the rivet holes. The removal of the burr makes a perfect stop-water. Most specifications now prohibit calking, and in Germany they are very strict in this regard.

Mr. M. A. Ryan has for past two years employed the air drill for removing burrs after the work has been drilled and then taken apart for this purpose. Since adopting this method he has materially reduced the percentage of leaking rivets. In circular sheets, especially, the greatest necessity exists for taking this precaution. Holes originally 13/16 inch can be reamed to 15/16 inch.

Capt. T. M. Rees stated that his foremen had refused to use oil, preferring coal, and he had thought maybe they were wrong; but the discussion has convinced him they were right. He had, however, seen the American Bridge Company getting good results by using a little valve right at the place where the heater could regulate his air supply, thus enabling him to heat the rivets very uniformly.

Mr. D. J. Champion, of the Champion Rivet Company, Cleveland, was asked to give his idea of the matter from a rivet manufacturer's standpoint, and said that the heating of rivets depended a great deal on the kind of tool used in driving them. He believed that the most successful heating was obtained with coal, natural draft and a high stack; the rivets must be heated to a cherry red, and never allowed to reach the point where they scale. When driven with a pneumatic hammer they sometimes want to be white hot. In the little hand forges the men sometimes blow them up with compressed air, because it is so much easier to bring them to a certain heat that way; but if heated in a common-sense way proper results will be secured.

In reply to a query by Mr. Wangler, Mr. Champion stated that he used fuel oil low in sulphur. If you heat rivets with fuel high in sulphur the sulphur from the fuel produces bad



J. F. WANGLER, TREASURER.

results by being absorbed by the rivets. Scaling comes from an excess of air in the furnace.

Mr. J. J. Main thought that it was more a question of temperature than kind of fuel; at a certain temperature the rivet is more apt to absorb the sulphur and form scale. When scale does form, notwithstanding all precautions, the rivet may be dipped in a pail of water, and then the scale will drop off, or the rivet can be thrown aside and the scale knocked off at some convenient time. If rivets are heated too hot and driven too fast, and put in hot they will afterwards contract in the hole and become loose.

Mr. H. J. Hartley reported that he had experimented with all kinds of fuel, and had finally come back to anthracite coal. It produces a more even temperature, and the rivet comes out cleaner.

President Meier called attention to the difference in oils, the Texas oils in particular running from 1½ to 3 percent sulphur. As Mr. Champion has said, at a previous convention, the thing to do in heating rivets is to take them when the heat is coming, not when it is going, in order to prevent scale formation.

Mr. G. H. Houston, of Cincinnati, referred to the fact that rivets when reheated after analysis showed a higher sulphur content and snapped off more readily. Mr. Rees said he did not believe there was a boiler manufacturer who had not had that trouble, especially when he commenced using steel rivets; but he owed Mr. Champion a debt of gratitude in having taught him how to keep out of it largely. His practice is to have only a few rivets heated at a time as they are needed, as he prefers driving fewer rivets, and driving them right, rather than having the rivets break off after riveting.

TUESDAY AFTERNOON SESSION.

Mr. John A. Stevens, member of the Massachusetts Board of Boiler Rules, representing the boiler users' interests, was introduced, and briefly acknowledged the compliment paid him in being called on to address the convention. He said the interests he represented had been most fairly treated by the board and had no complaint to make; that while some of the requirements had called for the expenditure of more money they were generally recognized as being for the best conservation of life and property. He offered any assistance he could render to the work of the A. B. M. A.

Col. Meier resumed the discussion of topical question No. 3, calling attention to the fact that in steel the transverse strength of the metal is nearly as great as the longitudinal strength.

Mr. Connelly favored using only one sheet until you get above a certain pressure, then they ought to be made in rings.

Effect of Gas, Water and Electric Power on the Steam Boiler Trade.

Mr. Scannell, of Lowell, Mass., stated that there were not so many small upright boilers made and sold in his section as there were before the general introduction of electric power; electric motors are in a measure displacing them.

Mr. Connelly, of Cleveland, reported that in his section of country they are using a good many gas engines and gasoline engines. Gasoline road rollers are being used, and for mixing concrete, for which formerly they used boilers and steam power. He himself employed gasoline for obtaining air pressure for outside work.

Col. Meier said that at Gary, in the new steel works there, they have a number of large gas engines with several thousand horsepower capacity; the difficulty with gas engines at present is the regulation, but the time is fast approaching when this will be remedied. The United States tests at St. Louis of comparisons between steam-engine and gas-engine efficiencies had shown very good results on gas engines down to 1.7 pounds per horsepower, even 1.25; and the stand-by losses were not any larger in gas producer than in steam engine plants; 1.35 was a fair average of test results on stand-by losses. That cannot be had with the highest type of steam engine and very expensive plants. The main difficulty is to find a way to use bituminous coal to best advantage with gas producers; they have obtained the best results with coke and anthracite.

Mr. Connelly thought there were not 25 percent as many steam boilers used for drilling as there were twenty-five years ago. Gas engines are taking their place.

Mr. Stevens said that aside from being more expensive than steam the gas engines were not so reliable, being irregular and not dependable, and the users got disgusted with them.

Mr. Houston commented on the fact that in this country the full economy of small steam engines has never been fully developed, as it has in England, by the use of superheating, equaling the best economy reached by any gas engines at present on the market.

Mr. Stevens corroborated this statement, and said that everybody on the other side of the water, where he had spent some months in studying the situation, was using superheat to advantage down to the smallest sizes of steam engines. The superheaters are simply constructed, and there is no reason why a similar practice cannot be adopted in this country to great advantage.

Mr. George N. Riley inquired of Mr. McNeill whether in his experience he had found that boilers are diminishing and being superseded by other power?

Mr. McNeill replied that in the larger centers of population electrical power plants are furnishing power to many of the smaller manufacturing plants for motor-driven machinery, where there is no necessity for using steam for mechanical purposes. On the other hand, the economical installation of steam plants is being made much more of a study than ten years ago, and successfully so. Formerly it was no uncommon thing to see a steam plant being put in without any provision being made for the heating of the feed water, thus instituting a large element of loss. Under the careful plans now being followed the steam plants must maintain their position for some time to come, as being a reliable source of power.

In reply to a query by Mr. Connelly, Mr. Stevens said that the prevalent practice on the other side in the use of superheat was a series of tubes with smaller tubes inserted in them, the steam being passed through the smaller tubes, in the Galloway type of boiler a simple steam drum or rectangular box and U-tube running down past the end of the boiler. They use all the superheat they can get in operating engines; the favorite type are attached to the boilers. The steam is taken out of the top of the boiler and exposed to the action of the superheaters, which are exposed to the flames direct.

Mr. Stevens stated that with internally-fired boilers superheaters are installed which extend through the rear end of the combustion chamber, utilizing the gases after passing through the under part of the shell. Automatic engines with automatic governors are coming into more general use. In sawmills these are used, burning refuse.

Mr. Connelly spoke of the difficulty experienced in early days in getting plate that would stand the heat of superheaters that were used in refining oil vapor, in order to take out the sulphur in the oil. He asked whether similar difficulty is now found to get plate that will stand the high heats of superheating.

Mr. McNeill replied that the Foster superheater has a series of steel tubes encased with cast iron rings that receive the direct impact of the gases, and the temperature of the internal pipes remains more constant with the furnace temperature of the gases passing up through the chimney, and the pipes under pressure are thus protected from direct impact with the gases by the cast iron sleeves. In the watertube boilers the superheaters are put in the upper part and not exposed to as high temperatures. In a case that came up recently one of the rules formulated by the Board of Boiler Rules stated that where the temperature of the superheater is over 80 degrees all pressure parts should be of cast steel, and the contract called for superheat of a minimum temperature of 75 and maximum 105 degrees.

Secretary's Report.

Secretary Frasey's report showed that the association was neither gaining nor losing in membership. There appeared to be a growing interest in the association, and many letters had been received from non-members, but they did not attend the convention.

Mr. George Wagstaff, of the American Locomotive Equipment Company & Railway Exchange, Chicago, first president of the International Master Boiler Makers' Association, addressed the convention, appearing as a special delegate from that organization. He explained that his principal object was to ask the co-operation of the American Boiler Manufacturers' Association in forwarding the work of the international association. He believed that the manufacturers would benefit by encouraging their foremen to attend the meetings and derive all the benefit they could from the valuable papers and discussions presented.

On motion of Mr. Riley the A. B. M. A. agreed to purchase copies of the proceedings of the international association sufficient to supply both their active and associate membership, and at a later session Mr. John J. Main was appointed a special delegate to attend the next year's convention of the International Master Boiler Makers' Association.

WEDNESDAY MORNING SESSION.

Commander R. S. Griffin, who had been especially delegated by the Navy Department to attend this meeting, bearing letters from Rear Admiral H. I. Cone, was introduced by President Meier, and spoke briefly on the navy requirements for steam boilers.

Uniform Specifications.

(See page 254.)

Col. Meier stated that committee R of the A. S. T. M., although it split on the subject of steel specifications, were unanimous in regard to the yield point question. The committee is composed of consulting engineers, steel users and steel makers, and it unanimously objected to the introduction of the yield point as a factor in determining the strength of materials.

Mr. Hartley said that it is not unusual to raise the yield point in a piece of steel without affecting the tensile strength. Whenever the elastic limit does not hold quite up to specifications by treatment with a hammer the elastic limit can be run up. Therefore the elastic limit is an unsafe test for determining the strength of boilers. He believed it would be a dangerous thing to change the old mode of calculating the strength of boilers; in order to avoid confusion and probable litigation, and even as an equitable matter in estimating on work, you should adhere to the old rule. It is not practicable, anyway, to exactly ascertain the yield point without running a little over.

Capt. Rees did not know of any testing machine that would give an exact result as to the yield point.

Mr. W. H. S. Bateman thought that while too much stress could not be laid upon the question of elastic limit, specifications at the present time, so far as physical requirements are concerned, were being conformed to by all the plate mills in the country without any difficulty.

Mr. Leonard, of Canada, said that the question of uniform specifications is being agitated in Canada by boiler manufacturers very seriously; there are at present too many conflicting laws in the various provinces which are embarrassing to the manufacturer in the practical operation of his business. The Canadian manufacturers follow pretty closely the practice on the American side.

Mr. Joseph H. McNeill, chief inspector of the Boiler Inspection Department and chairman Board of Boiler Rules of Massachusetts, appearing as a special representative of the Commonwealth of Massachusetts, under authority from his Excellency Governor Eben S. Draper, gave a resumé of the boiler inspection laws of Massachusetts and the work connected therewith from 1893 to date, including the work of the Board of Boiler Rules from the date of their appointment, July 5, 1907, to date, showing that this board is ever ready to accept suggestions for the betterment of the regulations, giving every point brought to their notice careful and unbiased consideration. In this way the results reached are the combined efforts of the best boiler engineering practice of the country, if not the entire world, as directed to the conservation of life and property, in the construction, installation and inspection and operation of steam boilers. There are about 20,000 power boilers in the State of Massachusetts.

Mr. H. J. Hartley gave the results of a careful comparison of the revised rules issued January, 1909, by the Board of Supervising Inspectors of the Steamboat Inspection Service, Department of Commerce and Labor, with those formerly in vogue, and which were the subject of much complaint because not adapted to modern conditions, stating that on the whole the present revised rules are much improved, with the exception of the clause relating to the thickness and tensile strength of steel that goes into boilers intended for use on vessels plying on Western rivers that empty into the Gulf of Mexico or their tributaries. That is unsatisfactory, because it leaves them in the same predicament that they were before when they were trying to get higher pressures.

Capt. Rees stated that the changes for the better in this book of rules had been accomplished entirely through the efforts of the A. B. M. A. committee meeting the board appointed by the president in October. After that it appeared that the inspection service took up the matter and made the revision, and took up the matter of the measurements on externally-fired tubular boilers, and corrected some of the matters that were causing confusion and embarrassment to boiler manufacturers on the Western rivers. The revision was rendered effective through the action taken in Congress, which was also brought about through our efforts largely. Credit should be given to the Congressmen who aided in this work, prominent among whom was Congressman Dalzell, of Pennsylvania. Up to the present time, however, in the rules promulgated last there is the difficulty that, with the .38-inch shell, it is not allowed to be stamped over 62,000, and this does not give the factor of safety that will permit of the pressures necessary and desired. Capt. Rees urged that the A. B. M. A. put itself on record that plates tested should be stamped at the tensile strength they are actually pulled by the government inspector. He had paid 1.1 cents more to get it as he wanted it, and wished to get the full benefit of the tensile strength he paid for. Capt. Rees also contended that as to flue diameters, as shown on page 37 of the January, 1909, issue of the *Rules of the Steamboat Inspection Service*, working pressures should be calculated and determined up to 16 inches diameter instead of stopping at 13 inches.

Col. Meier expressed his agreement in the stand taken by Capt. Rees, that the tensile strength should be stamped at the actual pull, and not arbitrarily fixed at 62,000, when it might be actually 70,000.

On motion it was resolved that it is the sense of the A. B. M. A. that such boiler plate should be stamped at exactly what it pulls as tested by the inspector, the reasons for this request being given in full.

A resolution was also adopted that the A. B. M. A. revert to its original specifications as to sulphur and phosphorus in boiler-plate material, because the compromise made at one time with the American Steel Plate Association has not been lived up to by them.

In support of the above motion it was stated that the steel men have ignored the former specification, which was .035 sulphur and .04 phosphorus, and have raised the percentage of both in both basic and acid steel, and have had their action endorsed by the action of the American Society for Testing Materials upholding a decidedly inferior specification to that maintained by the A. B. M. A. The printed specifications of the Pennsylvania Railroad for their own locomotive material showed that they were not satisfied with the specification that has been endorsed by the A. S. T. M., but that they were asking and getting, as large purchasers from the steel mills, what they demanded in the way of low sulphur and phosphorus for boiler and fire-box material.

Commander R. S. Griffin stated that there is no difficulty in getting steel of the requirements specified by the A. B. M. A. specifications, and that the Navy Department gets it right along; but there is generally a great deal of delay in getting it, and the contractors who have the work to do for the department state that very frequently the mills do not want to roll it to those specifications, that the orders are too small and it would not pay, and the price is very much higher than is paid for commercial steel; and in recent years the Navy Department has specified for many boilers for tugboats and auxiliary vessels steel plate conforming to the Supervising Inspectors' rules only. Such action was taken for the reason that it is cheaper, and also because an appreciable saving resulted from getting this steel. When the ships had nothing but Scotch boilers the department had no difficulty in getting steel plate from the mills to meet the requirements of boiler plate low in sulphur and phosphorus, and it is only since the abandonment of Scotch boilers for use in battleships and large cruisers that the department has used any low-grade steel specified by the Supervising Inspectors.

Col. Meier predicted that before very long the steel plate manufacturers will be furnishing boiler plate even better than that now contended for by the A. B. M. A., and that without any trouble, and Capt. Lappan concurred in this view, and held that improved processes which are now being investigated, probably by the employment of vanadium and other improvements, will produce a boiler plate that will not only be better than the most exacting demands of the present as to low sulphur and phosphorus, but will exceed present demands as to tensile strength and elastic limit and reduction of area.

Commander Griffin, in this connection, also stated that the experience of the department right along has been that you cannot depend on the elastic limit as showing any characteristic of the plate material, because this could be too easily manipulated, and no one can tell certainly what the point of rupture is.

THURSDAY MORNING SESSION.

The committee on time and place of next meeting, Mr. C. J. Wangler, chairman, reported in favor of Chicago for 1910, and the report was unanimously adopted.

The present officers of the association were re-elected for the ensuing year.

It was voted that next year's convention should last four days, beginning on Monday, the dates to be hereafter determined.

Resolutions of thanks were adopted to the following: Hon. Philip Breitmeyer, Mayor; Mr. Joseph McNeill, chief inspector and chairman Massachusetts State Board of Boiler Rules; John A. Stevens, member of said board; Mr. J. C. McCabe, chief boiler inspector, Detroit, Mich.; Mr. George Wagstaff, of the International Master Boiler Makers' Association; to the associate members and committees; to Messrs. T. H. Simpson and R. H. Phillips, of the Detroit Seamless Steel Tubes Company; to the manager of the Hotel Ponchartrain; to the local and technical press.

A special vote of thanks was tendered to his Excellency, Hon. Eben S. Draper, of Massachusetts, for sending special representative McNeill to the convention. Similar acknowledgement was made to Rear Admiral H. I. Cone for sending as a special representative Commander Griffin. The request was added that the department make it an annual custom to delegate a representative to attend the meetings of the A. B. M. A.

The remainder of the morning was taken up in executive session, and the convention then adjourned *sine die*.

Entertainment.

As usual the entertainment features of the convention were provided by the associate members and supply men. The programme this year was under the immediate supervision of the following committee: J. F. Duntley, T. H. Simpson, George W. House, George H. Hayes, F. S. Werneken, R. H. Phillips.

The programme included a reception for the ladies in the parlors of the Hotel Ponchartrain on Tuesday morning, Aug. 10, and an automobile ride for the ladies Tuesday afternoon. Tuesday evening a theater party was held at the Temple Theater. Wednesday morning various points of interest were visited by the ladies, under the guidance of the entertainment committee. In the afternoon the entire convention boarded the steamer *Pleasure* for a cruise to the St. Clair Flats. Luncheon was served on board, and there was music and dancing until the boat returned to her dock in the evening. Thursday morning an automobile trip was arranged to Belle Isle, where luncheon was served, and in the evening the annual banquet was held at the Hotel Ponchartrain.

Notes Concerning the Associate Members and Supply Men

Officers of the supply men's organization were re-elected as follows: W. O. Duntley, president; J. T. Corbett, vice-president; H. B. Hare, treasurer; W. H. S. Bateman, secretary.

A new constitution was adopted by the supply men's organization, and the name of the association was changed to the Supply Men's Association of the American Boiler Manufacturers' Association.

The associate members gave souvenirs in the shape of a hand-painted china plate, and the Champion Rivet Company also distinguished themselves by presenting a handsome souvenir.

Mr. C. C. Swift, representing the Cleveland Punch & Shear Works, kept "open shop" in parlor 414, where he exhibited to all callers a reduced model of one of their large 24-inch C machines for punching an inch hole through a ½-inch plate and shearing ½-inch plate. The model weighed 200 pounds, and was an exact replica of a 7,000-pound machine, complete in every detail. It was equipped with automatic electric motor drive, showing operation, running thirty-five strokes per minute. It is of solid frame-type construction, which eliminates the core and puts the metal positively where it will do the most good.

Messrs. W. H. S. Bateman, of the Parkesburg Iron Company and Champion Rivet Company, and H. B. Hare, of the Otis Steel Company, entertained callers at their rooms, where samples of the product of the various companies which they represent were on display.

The following attended the convention: J. L. Adams, Champion Rivet Company, Cincinnati, Ohio; Thomas Aldcorn, Chicago Pneumatic Tool Company, New York, N. Y.; Douglas A. Brown, official reporter A. B. M. A., Cincinnati, Ohio; Henry Brobst, Mrs. H. Brobst and Miss Pierce, Central Boiler Works, Grand Rapids, Mich.; W. H. S. Bateman, the Parkesburg Iron Company and Champion Rivet Company; G. W. Bostwick, National Tube Company, Pittsburg, Pa.; Hon. P. H. Breitmeyer, Mayor of Detroit, Mich.; M. M. Brien, boiler and elevator inspector, Nashville, Tenn.; M. H. Broderick and wife, Broderick & Quinlan Manufacturing Company, Muncie, Ind.; A. J. Becker, the McNeil Boiler Company, Akron, Ohio; D. Connelly and wife, D. Connelly Boiler Company, Cleveland, Ohio; J. T. Corbett, Joseph T. Ryerson & Son, Chicago, Ill.; D. J. Champion and wife, Champion Rivet Company, Cleveland, Ohio; William H. Connell, Jr., Hilles & Jones Company, Wilmington, Del.; J. B. Corby and wife, Corby Supply Company, St. Louis, Mo.; F. J. Carney, secretary Boiler Inspection Department, Detroit, Mich; C. M. Chamberlin, A. M. Castle & Company, Chicago, Ill.; Miss A. B. Chute, Enterprise Boiler Company, Youngstown, Ohio; J. B. Campbell and wife and Miss Hannah Viall, McNeill Boiler Company, Akron, Ohio; J. F. Duntley, Chicago Pneumatic Tool Company, Detroit, Mich.; Charles E. Doyle, city boiler inspector, Providence, R. I.; O. J. Dunkelberg, chief assistant boiler inspector, Detroit, Mich.; Jas. D. Farasey and wife, H. E. Teachout Boiler

Works, Cleveland, Ohio; J. J. Finnigan, Mrs. W. H. McAlpin and Mrs. L. Walker, J. J. Finnigan & Company, Atlanta, Ga.; Fred. Gardner, Joseph T. Ryerson & Son, Chicago, Ill.; J. P. Hoelzel, Ft. Pitt Forge Company, Pittsburg, Pa.; George W. House, "Otis" and "Champion," Detroit, Mich.; H. B. Hare, Otis Steel Company, Cleveland, Ohio; George H. Houston, Houston, Stanwood & Gamble, Cincinnati, Ohio; H. J. Hartley, Miss Sue Crawford and Miss Emma Woodruff, Philadelphia, Pa.; George H. Hayes and wife, Chicago, Pneumatic Tool Company, Detroit, Mich.; William Kehoe, William Kehoe & Sons, Savannah, Ga.; Mrs. N. Laughlin, Cleveland, Ohio; F. E. Lawson, Detroit, Mich.; F. E. Leonard, E. Leonard & Son, London, Ont.; James Lappan, James Lappan & Company, Pittsburg, Pa.; Walter Long and wife, Walter Long Manufacturing Company, Pittsburg, Pa.; James T. Lee, Hanna Engineering Works, Chicago, Ill.; J. Lawton, boiler inspector Fidelity & Casualty Company, Detroit, Mich.; A. S. McEldowney and wife, Scully Steel & Iron Company, Chicago, Ill.; Joseph H. McNeill, chief inspector Boiler Department and chairman Board of Boiler Rules, Boston, Mass.; J. C. McCabe, chief inspector, Detroit, Mich.; H. D. Mackinnon and wife, Mackinnon Boiler Manufacturing Company, Bay City, Mich.; Austin M. Mueller, Joseph T. Ryerson & Son, Chicago, Ill.; Robert Munroe and wife, R. Munroe & Sons, Pittsburg, Pa.; John J, Main, Poulson Iron Works, Toronto, Can.; A. F. Martin, assistant boiler inspector, Detroit, Mich.; R. H. Phillips and wife, Detroit Seamless Steel Tubes Company, Detroit, Mich.; Capt. T. M. Rees, Pittsburg, Pa.; M. A. Ryan and wife, Northwestern Steam Boiler & Manufacturing Company, Duluth, Minn.; George N. Riley and wife, National Tube Company, Pittsburg, Pa.; H. D. Robertson, the Chicago Pneumatic Tool Company, Detroit, Mich.; Charles C. Swift, the Cleveland Punch & Shear Works Company, Cleveland, Ohio; W. C. Sayle, the Cleveland Punch & Shear Works Company, Cleveland, Ohio; A. J. Schaaf and wife, chief engineer Monongahela Con. River Coal & Coke Company, Pittsburg, Pa.; S. Severance, Severance Manufacturing Company, Pittsburg, Pa.; George Slate, THE BOILER MAKER, New York, N. Y.; John A. Stevens, member Board of Boiler Rules, Lowell, Mass.; Daniel Shea, D. Shea Boiler Works, Memphis, Tenn.; F. B. Slocum, Continental Iron Works, Brooklyn, N. Y.; J. Don Smith and daughter, Charleston, S. C.; Bartholomew Scannell, Dr. John Scannell, Miss Mary Scannell, Miss Katharine Scannell, Scannell Boiler Works, Lowell, Mass.; T. H. Simpson, J. F. Thrash, Dallas Boiler Works, Dallas, Tex.; T. E. Tucker, Gem City Boiler Company, Dayton, Ohio; M. Tibbals, Continental Iron Works, Brooklyn, N. Y.; George Wagstaff, American Locomotive Equipment Company, New York, N. Y.; Charles J. Wangler, Joseph F. Wangler B. & S. I. Company, St. Louis, Mo.; T. P. Wallace, W. G. Hagar Iron Company, St. Louis, Mo.; F. S. Weneken, John Brennan & Company; E. A. Ashley, Muskegon Boiler Works, Muskegon, Mich.; L. Beardsley, Chicago Pneumatic Tool Company, Chicago, Ill.; George M. Black, treasurer Detroit S. S. T. Company; Frank Cockburn, J. F. Corlett & Company, Cleveland, Ohio; W. O. Duntley, Chicago Pneumatic Tool Company, Chicago, Ill.; T. L. Dodd, Worth Bros.; Samuel A. Fortson, vice-president Lombard Iron Works, Augusta, Ga.; Commander Robert S. Griffin, United States Navy, Washington, D. C.; L. E. Geer, Manitowoc Boiler Works, Manitowoc, Mich.; W. E. Graham, Carnegie Steel Company, Detroit, Mich.; Charles Hayes, Chicago Pneumatic Tool Company, Detroit, Mich.; J. Lawton, boiler inspector, F. & C. Company, Detroit, Mich.; George Spry and wife, Marine Boiler Works Company, Toledo, Ohio; Mr. Scott, Cramp & Son, Philadelphia, Pa.; J. H. Williams, John Brennan & Company, Detroit, Mich.; Capt. Westcott, United States Supervising Inspector, Detroit, Mich.; C. M. East, Murphy Iron Works Company, Detroit, Mich.

DESIGN OF STEEL STACKS.

BY BIRGER F. BURMAN.

If anybody takes the trouble to investigate the strength of one of the steel stacks on his plant, he may be surprised to find how weak the shell is, not in the plate, but in some of the lower horizontal rivet joints. That the stack has not already succumbed or been blown down is due, not to the shell, but to the solid protection of the brickwork inside. Thanks to the great weight of this brickwork, reinforced, so to speak, by the steel shell on the outside, there is, as a rule, absolutely no danger of its being blown down. If, however, a brick-lined draft stack should fall, the cause of the mishap may, perhaps, be found in badly laid brick courses; the rivet joints exposed to the oxidizing influences of the fumes will in time be weakened, and when they thus have to carry greater load per unit of rivet area, it is evident that the stack sooner or later will give way. In order to prevent such a sad and costly experiment, it is best to lay the brick lining very carefully and design the shell properly.

As the erection of smaller stacks usually gives the engineer a chance to support them laterally higher up on the shell by means of rods, etc., their design will be simple enough. A thin cylindrical steel shell will withstand any pressure from the wind. We will, therefore, consider conditions governing larger stacks where any support of the shell from the outside is out of question.

If we had no wind to contend with, it would simply be a matter of designing the shell for the dead weight alone. However, by far the greatest strains are just those that are caused by the wind, and as 50 pounds per square foot generally seems to be considered a maximum pressure for wind, we will here adapt it and use a factor of two-thirds for stacks with circular sections.

If the brick lining were built up close to the shell, far less would be needed; an ideal section would be a reinforced concrete one. In case of shells where the brick lining is not put in at once a heavier construction is required than where such lining is built.

Any section of the shell has to take care of stresses due to the dead weight above it, and those due to the wind pressure. If it is only a question of checking the strength of a shell already erected, time may be saved, with sufficient accuracy for practical purposes, by assuming the area of the stack above any given section as a true rectangle, with the mean diameter as one side, and the resultant force of the wind pressure acting at a point half way up. The formula below, treating the stack as a beam of uniform section loaded uniformly and worked out accordingly, gives results somewhat too large:

$$Mb = \text{overturning moment} = \frac{D + d}{2} \times H \times 50 \times 0.67 \times \frac{H}{2} \times 12 \quad (1)$$

$$= 100.5\, H^2\, (D + d) \text{ inch-pounds.}$$

Where D is the outside diameter in feet of the shell at any given point, d is the outside diameter in feet at top of shell, and H is the height of stack in feet above given point.

When the bending moment is found, proceed as described below (formulas 4 to 8) in order to find the actual unit stresses from wind pressure, and to this add stresses due to the weight of shell above. (See formulas 9 to 11.)

For more accurate calculations, although these are not necessary, as the wind pressure of 50 pounds per square foot and the factor 0.67 in formula (1) are both relative figures, either the center of gravity of area above the given section has to be found or a stress diagram laid out. Considering the first case, any engineer's pocketbook gives convenient rules for finding the center of gravity (see also Fig. 1) of a trapezoid, and the formula will be

$$Mb = \frac{D + d}{2} \times H \times 50 \times 0.67 \times H_2 \times 12 \quad (2)$$

$$= 201\ HH_2\ (D + d) \text{ inch-pounds,}$$

where H_2 is the height in feet of center of gravity above the given section.

If a large board is available the laying out of a stress diagram for getting at the bending moments may be practical. For this purpose consider each part between horizontal seams of the stack as a true rectangle, and through its center of gravity, which, of course, will be at the intersections of its diagonals, apply a force representing the wind pressure on that surface. See Fig. 2.

$$P = D_4 \times h_1 \times 50 \times 0.67 = 33.5\ D_4\ h_1 \quad (3)$$

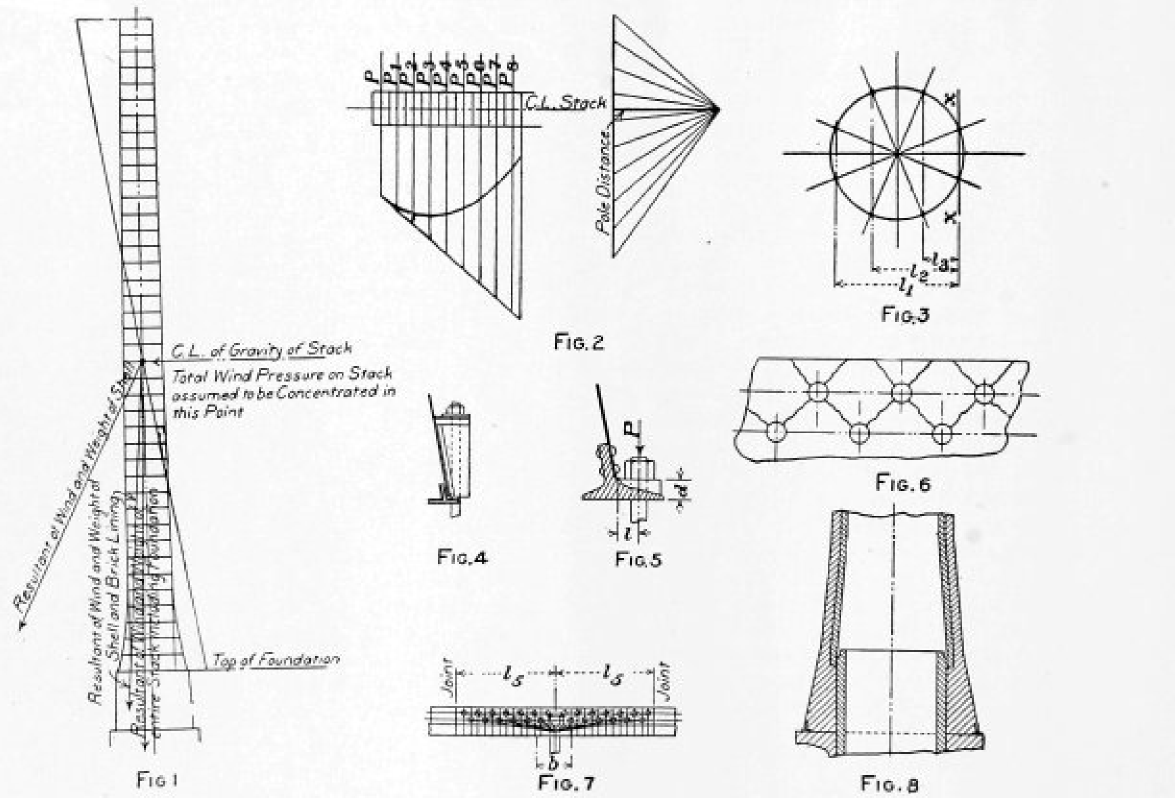
where D_4 is the mean outside diameter of this part of the stack in feet, and h_1 is the height of the part in feet.

$$Mn = \text{net overturning moment} = 0.098\ \frac{D^4 - D^4_2}{D} \times S$$

$$= 0.098\ S\ (D^4 - D^4_2) \div D,$$

as shown below. (See formula 4.)

When designing a shell for a new stack it will be necessary to assume some minimum thickness of the first plate section at the top of stack, as there is practically no strain on it. If ¼-inch plate, ½-inch rivets and 2-inch pitch be taken, the first horizontal seam may be figured out. To begin with, there is very slight increase in unit pressures, and for quite a distance down the shell there need be no change in either plate or rivets. By taking seam after seam downward it is possible to design the shell with fairly equal strains all through from a certain height, and to increase the thickness of the plate and the diameter of the rivets at the proper places. It will be found that certain seams, although the plate is plenty strong enough for tension and compression, require an increase in both number and diameter of rivets, in order to keep down the



DIAGRAMS ILLUSTRATING FEATURES OF STEEL STACKS.

When all the loads above the given section have been found, draw a force and equilibrium diagram, as shown in Fig. 2, choosing any convenient scale for the force polygon, the equilibrium diagram being laid out to the same scale as the shell. In reading off the bending moments, keep in mind that any ordinate in the equilibrium diagram to this scale in inches multiplied by the pole distance to the same scale as the force polygon gives the bending moments in inch-pounds.

After having thus found the total wind overturning moment for any section, it will be necessary to get its stability moment due to the weight of the shell above. By deduction, we get the net overturning moment which is to be used for calculating the unit stresses. The shell is a hollow cylinder at any point chosen, and the formula for unit stress will, therefore, be

high shearing and bearing values; and often the thickness of plate has to be increased just on that account.

Further down the shell, with the regular increase in its diameter, there is a point where even double riveting may not suffice. A more rapid increase in the diameter of the shell must then be provided for, in order to give room for a greater number of rivets in each row, and this is one of the reasons why the stacks usually are made bell-shaped at the bottom. Naturally, a wider base will place the anchor bolts further away from the center, thus decreasing the total pull on each bolt.

When the size of the stack has been determined, draw the center line and step off each plate section, making all of the same height. It will be wise to make them as large as possible without using too many vertical seams. Draw the center lines of all horizontal seams and fix the inside diameter of the plate at the top of the shell. Draw the outlines of the shell through these points, making the diameter of each succeeding seam somewhat larger, using the same increase all through. Try first with 1 inch or less, and when the trapezoid is laid out figure out the overturning moments from a wind pressure of 50 pounds per square foot, as stated above. Neglect in this preliminary calculation the weight of the stack and its stability moment, and on a diameter of about one-tenth of the height of the stack decide upon number of anchor bolts. Make calculations for them as shown in formulas 12 and 13, and if the results are satisfactory, begin calculations with seam 1 at the top. If the stack is to receive very hot gases the brick lining further down needs to be proportionally heavy, and for this reason also the shell has to be sloped more.

Keep records of each seam. The following may serve as an example, choosing any convenient one:

Horizontal seam 16. (All seams above have been figured out.)

H = height of stack in feet above seam.
h = height of plate section 16 in inches.
D = outside diameter of seam in inches.
D_1 = mean diameter of plate section in inches between seams 15 and 16.
D_2 = inside diameter of seam in inches.
D_3 = mean diameter of seam in inches.
d = outside diameter of shell at top of stack in inches.
n = number of rivets in one or two rows.
d_1 = diameter of rivets.
d_2 = diameter of rivet holes.
a = area of one rivet.
a_1 = area of one rivet hole.
p = pitch of rivets.
p_1 = pitch of rivet rows.
l = horizontal lap in inches.
l_1 = vertical lap in inches.
n_1 = number of vertical seams.
t = thickness of plate.
v = weight of 1 square foot of plate.
v_1 = weight of one rivet head.
W = weight of shell above plate section 16.

$$W_1 = \frac{(\pi D_1 + n_1 l_1)(h + l)}{144} V + 2nv_1 \text{ pounds.}$$

= weight of plate section 16

$W_2 = W + W_1$ = actual load on seam.
$A = H(D + d) \div 24$ = area in square feet of stack above seam 16.
H_1 = height of center of gravity of area A above seam 16 in inches.
$33.5\, A$ = total wind pressure on area A in pounds.
$Mb = 33.5\, AH_1$ inch-pounds = total wind overturning moment.
$Ms = W_2 D/2$ inch pounds = stability moment.
$Mn = Mb - Ms$ = net overturning moment.
$a_2 = an$ = total area of rivets for one seam, for shearing value.
$a_3 = d_2 nt$ = total area of rivet holes for one seam, for bearing value.
$a_4 = \pi D_3 t$ = single plate area for one seam.
$a_5 = \pi D_3 t - nd_2$ = net plate area (n is here number of rivets in one row only).

$Mn = 0.098\, S\, (D^4 - D^4_2) \div D$, from which formula S is given as unit stress in pounds per square inch for tension and compression in plate............................(4)
$T = Sa_4$ = total strain on one seam in pounds..........(5)
T/a_5 = unit stress in pounds per square inch of net plate area ....(6)
T/a_2 = shearing value of rivets in pounds per square inch. (7)
T/a_3 = bearing value of plate in pounds per square inch..(8)
W_2/a_4 = unit stress, in pounds per square inch of plate area ....(9)
W_2/a_2 = shearing value of rivets in pounds per square inch ....(10)
W_2/a_3 = bearing value of plate in pounds per square inch. (11)

Vertical seams are staggered so as not to give continuous seams from the top to the bottom of the stack. Each such seam may be assumed to be on the neutral axis of the shell section when the wind is blowing and there will be no stress on it, or the one part between two horizontal and two vertical seams may be assumed to receive that part of the wind which

TOTAL UNIT STRESSES.

	Tension and Compression.	Shear on Rivets.	Bearing on Plate.
Due to weight of shell..........	W_2/a_4	W_2/a_2	W_2/a_3
Due to wind	T/a_5	T/a_2	T/a_3
Total	$\frac{W_2}{a_4} + \frac{T}{a_5}$	$\frac{W_2+T}{a_2}$	$\frac{W_2+T}{a_3}$

acts directly on it, a very insignificant load indeed. Therefore, there may be only crippling of the seam to be considered. The resultant force from the wind and the weight of the shell above may be assumed to act on one-half of the circumference, one seam taking an amount equal to its lap, which again will be found to be relatively small. For practical purposes it will be close enough to use the same rivets as in the horizontal seam; they must, however, be always in a single row.

At the bottom of shell a footing must be provided in order to distribute the load on the foundation. A conservative pressure of 5 tons per square foot (with no wind blowing) on concrete and good brick may be chosen, and the foot designed accordingly. First, however, make calculations for the anchor bolts, the diameter of bolt-circle being given when due allowance for the footing outside of the bottom of the shell has been provided for. A comparatively large number of bolts is preferable; the pull that may occur will then be better distributed to the foundation, especially if the bolts are made of different lengths.

Referring to Fig. 3, the net overturning moment for bolts, which always will be somewhat smaller than that for the last seam, on account of the added weight of the footing, has to be taken care of by the resisting moments Mr of the bolts. Assuming, therefore, that the overturning will take place over the line $x - x$, the sum of each bolt's resisting moment shall equal the overturning moment of the stack.

$$Mn = Mr = 2l_1q + 2l_2q + 2l_3q \text{ inch-pounds.} \qquad (12)$$

By solving for q, which is the load on the bolt section, the formula will be

$$q = \frac{Mr}{6\,(l_1 + l_2 + l_3)} \text{ pounds.} \qquad (13)$$

The diameter of the bolt is readily found from this equation. Should the result be rather large, make another calculation for ten or twelve bolts until a satisfactory design is reached.

Bolts having been decided, the footing may be designed. As the pressure exerted by the shell on the foundation will be found to be relatively small, a couple of heavy angle-irons, as shown in Fig. 4, will often be ample to give proper unit pressure. In this particular case the maximum load on the rivets in the footing is the resultant force of wind and weight of shell, and consists merely of compression, the bolt brackets, made of structural material, taking care of the entire pull due to the net overturning moment. However, such a footing may often not be desirable; a neater looking one is a simple base plate made of cast steel in as many sections as there are bolts, as in Fig. 5. This plate requires a careful design, as the section is not a favorable one, considering the kind of work it has to do. There are the strains caused by the pull on the bolts, and the following formula may be used to determine the thickness of metal, on the assumption of a beam loaded at the end:

$$Mb = Pl = 12{,}000\ bd^2 \div 6, \qquad (14)$$

where P is the load on the bolt in pounds, determined by formula 13, and b is the width of the heavy part of the footing under the nut.

The next step is to find the thickness of metal in that part of footing to which the shell is riveted. There are two kinds of stresses acting here: shear and tension from the rivets and bending from the anchor bolts. Formula 5 gives the total load transmitted into the footing, and this load exerts through the rivets a pull and shear on the metal. If there are two rows of rivets, each row takes care of half of the load. In Fig. 6 the broken lines represent the direction of possible breaking lines of metal. However, the shortest distances may be found to be on the center line of the rivets; therefore, by figuring out the net area between rivet holes:

$$\text{Net area} = t_{\cdot}\ (\pi D_1 - nd_2) \text{ square inches}, \qquad (15)$$

and dividing it into the half load, we get a unit stress for tension which, for cast steel, would require a comparatively thin metal. We must, therefore, analyze the total section for bending, so as not to make a bad mistake. In Fig. 7 the pull on the bolt is graphically shown, the distance b being given from formula 14. We may, for simplicity, consider the pull as a load uniformly distributed on a beam supported at one end on b, the required section modulus of the beam being eliminated from the formula:

$$Mb = (l_2P/2) \div 2 = 12{,}000\ S \qquad (16)$$

As the cross-section is an irregular figure the moment of inertia has to be found, which for practical purposes it may be all right to figure out over a neutral axis that is horizontal; and after making several trials of different sections it will be seen that considerable more metal has to be furnished for the upper part of the base plate than formula 15 indicates.

The different sections are bolted together, care being taken not to have the vertical seams of the lowest plate section of the shell placed directly over any joint of the footing. There need be no heavy bolting of the joints, as the strains disappear into the shell at these points.

In view of the great confusion that exists regarding the length of the anchor bolts, the engineer may be justified in making a guess and bury a lot of unnecessary steel in the foundation, especially when "the cost is so trifling on such a big job."

As the foundation washer is the medium through which the pull on the bolts is transmitted to the foundation, its proper design is of much importance. Decide upon the square-shaped kind, and make its net area large enough for a pressure of 10 tons to the square foot. Use formula $Pl/2$ to determine the thickness of the metal at the bolt head, P here being that part of the total pull on the foundation bolt which acts on, say, 1 inch width of the washer, and, besides, investigate for shear. Do not allow too high a bearing pressure on the foundation, because, while 10 tons is a good average load and easily could be increased for concrete and a good brick foundation, it is desirable to get a rather large washer and thus better distribute the load in the foundation. If possible, make bolts of two lengths by having every second washer on the same elevation.

Again, the pull on the washer has to be resisted by the foundation itself. This resistance will be the weight of some assumed part of it above the washer plus that resistance to shear which is produced by pulling this part from the rest of the foundation. Whether the imaginary breaking lines starting out from the wedges of the washer in all directions go straight up or at some angle is hard to tell. To be on the safe side assume a vertical breakage if that is the shortest distance, and use a conservative figure for shear.

Finally, the distribution of the foundation on a sufficiently large area of the soil has to be looked into very carefully, so as to get the proper bearing pressure; and it will be the resultant force of wind pressure and weight of total stack and foundation, always acting under an angle, which will determine the load on a somewhat diminished area, as the center of pressure will be more or less eccentric.

Referring to Fig. 1 we note the directions of the different resultant forces. As may be easily understood a brick-lined steel stack, if properly designed, is very stable; and if the lining is laid tight up to the shell there will probably be comparatively small stresses in the shell and foundation bolts. However, it would not be wise to build a stack having this large stability moment in view, especially as we do not know when the shell might be lined after its erection.

Many large stacks are built with the lining going clear through the shaft from top to bottom as a hollow cylinder. The unit pressure at the bottom is exceedingly high, 25 to 30 tons per square foot if a high wind is blowing. To avoid this, build the lining as shown in Fig. 8; the unit pressure will be decreased, while it will act more uniformly over the entire foundation.

From what has been shown above there is an economical limit to the size of steel draftstacks above which it is better to build several small ones, because in very high stacks much steel goes to waste in the shell and the lining will be difficult to care for in respect to unit pressure, etc.—*The Engineering Record.*

UNIFORM BOILER SPECIFICATIONS.

The committee on uniform boiler specifications of the American Boiler Manufacturers' Association, of which Col. E. D. Meier is chairman, presented the following report at the annual convention of the association recently held in Detroit:

In our report of last year we gave you as exhibit "B" a report made by a committee of the American Society for Testing Materials (of which your chairman has also the honor to be chairman), recommending for their adoption the original limitations as to sulphur and phosphorus, as found in the specifications of the A. B. M. A. of 1889. This report was signed by the majority of the members of the committee, five in number, representing steel users, while two of the members, representing steel plate manufacturers, refused to sign it and made strenuous opposition.

This report was referred to the committee on steel specifications of the A. S. T. M., being their committee "A." This committee "A" met in Philadelphia on March 1, 1909, to discuss the matter. Your chairman addressed the letter of Feb. 25, 1909, to this committee "A," which is hereto appended as exhibit "A."

This report again had the assent of the majority of committee "R," but in spite of this the committee "A" has published specifications with the high phosphorus complained of, and has even increased the permissible percentage of sulphur.

This action was taken in spite of the strenuous protest of Mr. Henry J. Hartley, one of the original members of your committee. Your chairman, therefore, addressed a strong protest to the American Society for Testing Materials at their convention in July, of this year, a copy of which is appended as exhibit "B." This again had the sanction of the majority of the committee, but, as above stated, was disregarded.

We beg to call your attention to the report we made to you on Dec. 22, 1905, reporting a memorandum of agreement between a committee from the American Association of Steel

Manufacturers and your committee on uniform specifications, in which an agreement was reached to compromise on the percentage of phosphorus and sulphur. This compromise was adopted by the A. B. M. A. without dissent, but it afterwards transpired that the committee of the A. A. S. M. had no power to bind their association, for on Jan. 20, 1906, that association resolved to sanction this agreement only so far as it referred to the A. B. M. A., but maintain the standard specifications of the A. A. S. M. of Feb. 6, 1903, as the basis for the general trade.

Now, in view of this action of the steel plate manufacturers and the exercise of their influence against our compromise before the committee of the American Society for Testing Materials, your committee deems it but proper to confess that the agreement with the committee of the A. A. S. M., published to our membership on Dec. 22, 1905, on page 164 of the proceedings of the seventeenth annual convention, 1905, has become invalidated and to recommend the readoption of the original specifications of the A. B. M. A. as to sulphur and phosphorus. These specifications agree with those of the U. S., Navy Department for the same classes of steel.

Your committee further reports that Mr. Joseph H. McNeill, chairman of the Board of Boiler Rules of the Commonwealth of Massachusetts, addressed a letter to the A. B. M. A in the following words:

"This Board desires an expression of opinion from you as to the advisability of making provision in the rules so as to take into consideration the yield point of steel, when the lowest yield point is stamped on the plates (in addition to the stamps of tensile strength), for calculating the maximum allowable working pressure on shells and drums hereafter constructed."

To which, after consultation with members of the committee, your chairman replied as follows:

"First: As most boiler laws and regulations specify a factor of safety of five, and in some cases six, which is universally understood to be based on the ultimate tensile strength, the introduction of the elastic limit or yield point as a basis for the factor of safety would reduce it to between two and a half and three, and would lead to confusion.

"Second: There is always greater difficulty in determining the exact value of the elastic limit or yield point than the tensile strength. Only the best modern machines will give this with reasonable accuracy, and all testing machines of the older type—on which many committees have learned to rely—would become obsolete if this were introduced.

"Third: Only engineers and specialists would, in the beginning, understand this new factor safety, and the general public might easily misunderstand and think the standards had been lowered.

"Fourth: This matter has been gone into in the past by engineering societies and testing bureaus, and the conclusion reached that no satisfactory benefit would be gained therefrom.

"Fifth: The general practice of specifying that the elastic limit shall never be less than one-half the ultimate tensile strength seems to cover all the advantages which could be obtained from introducing the practice suggested.

"Sixth: The introduction of this new provision would naturally lead to the use of two different methods—the present one and the new one—for calculating the strength of boilers.

"The question you raise is not an easy one to answer. I remember that at least fifty years ago engineers in Germany suggested that the practice of figuring the factor of safety on the ultimate tensile strength of the material was irrational, because, when the elastic limit is reached, the usefulness of the material is gone. But the practice has nevertheless continued, and to change it now might be very misleading For instance, if you have specified by law or regulation a factor of safety of five, this would universally be understood to be based on the ultimate tensile strength, as the elastic limit or yield point, which are generally very close together, is about one-half of the tensile strength you would have to specify a factor of safety of two and a half based on the yield point.

"One obstacle to basing the factor of safety on the elastic limit has always been the difficulty of determining the exact value of the elastic limit. Only the more modern test machines give reliable data. Now, in point of fact, there are a great many very good testing machines of the older type on which the community has learned to rely. If you now exact a factor of safety based on either the elastic limit or yield point, you would probably render useless quite a lot of testing machines which have heretofore been considered valuable.

"Again, only engineers and specialists would understand the meaning of this new factor of safety, whereas the general public might easily get confused and think that you had lowered your requirements.

"I think that so radical a change should be very carefully considered, and that consulting engineers and steel mills which furnish boiler plate should be heard on the subject. Personally, I have always proportioned my boilers and all my work so as to be well inside the elastic limit.

"I would respectfully suggest that you write to the American Society of Mechanical Engineers, as well as to the American Society for Testing Materials, as to their views on this subject."

Three members of your committee in February last met with the commission appointed by President Roosevelt for the revision of the laws for greater safety of life at sea, and discussed with them various phases of the rules proposed.

We take pleasure in reporting, further, that in the State of Texas, and in the city of Detroit, the matter of inspection laws for boilers has been seriously taken up; while in Texas the legislation proposed was defeated, those in charge of it intend to take it up again in the next legislature. In Detroit an elaborate and carefully considered ordinance, based largely on our uniform American specifications and on the boiler rules of the Commonwealth of Massachusetts, has been passed, and will be brought up for discussion in the course of our convention.

This shows, then, that the effects of previous committees of this association on uniform inspection laws, which at the time, to the great disappointment of our members who worked so hard on them, seemed futile, have proven to be the good seed from which sound laws and ordinances governing the construction and inspection of boilers will grow. Any one who will carefully read the history of this association cannot escape the conclusion that all these movements—National, State and municipal—for the better construction of boilers, have grown out of the conscientious and persistent efforts of the American Boiler Manufacturers' Association, in demanding the highest quality of materials and workmanship for standard American boilers.

Exhibit "A."

FEB. 25, 1909.

Chairman and Members of Committee A, of the American Society for Testing Materials:

GENTLEMEN:—The report of committee R of this society of June 10, 1908, has been referred to you in order to decide on the recommendation contained therein for a change in the specification for steel boiler plate of this society. This recommendation was signed by six members of the committee only; two of the members, Messrs. Huston and McLeod, dissented therefrom. We deem it best to place before you a short historical review, giving the facts on which the majority based their recommendation.

Before 1889 there were no specifications for boiler plate in general use in the United States. Builders of stationary, marine and locomotive boilers contented themselves with simply specifying the brand of the steel, such as Otis, Park Bros., Black Diamond or Marine. The material was accepted on faith. In October, 1889, the American Boiler Manufacturers' Association (hereafter designated as A. B. M. A.), at Pittsburg in convention assembled, drew up and unanimously adopted a specification for boiler plate, after a full and complete discussion of the requirements with a number of representatives of steel plate manufacturers, who were given the full privilege of the floor. Some of the steel plate manufacturers did strenuously object to these specifications, declaring they were too hard to fill. Thereupon Mr. Charles Schwab, at the time general manager of the Homestead Works, declared that he could and would make this steel. He did so, and the others shortly after fell in line. After this these specifications were filled without any adverse criticism until about 1898. At that time the A. B. M. A., finding that these specifications were not only easily filled by various steel works, but that the maximum sulphur and phosphorus limits were rarely reached in practice, decided to make a slightly better specification.

The chairman of the committee on materials reported that out of 294 chemical tests of A. B. M. A. from plates made by eight different steel mills the average phosphorus was .022, and the average sulphur was .024, and concluded that if moderate specifications are made the healthy competition and business pride among American steel makers will induce them not only to reach, but improve, on the quality specified. But soon after this the steel makers began to protest against these new specifications, and the Association of American Steel Manufacturers (hereafter designated as A. A. S. M.) agreed with the A. B. M. A. to a joint meeting of two committees, which took place Dec. 15, 1905, and an agreement was reached as to a joint specifications. This agreement was ratified unanimously by the A. B. M. A., but the A. A. S. M., on April 9, 1906, agreed to it only so far as it applied to A. B. M. A., but resolved to maintain its standard specification of Feb. 6, 1903, "as the basis for the general trade."

At the meeting of the joint committees, Dec. 15, 1905, the chairman of your committee R submitted results of 599 tests of boiler plate made in 1904, which showed the following results:

	Max.	Min.	Average.
Phosphorus	.031	.007	.016
Sulphur	.036	.013	.024

Of these only three went above the .03 sulphur limit; viz., two were .031 and one .036.

He, therefore, argued that a return to the A. B. M. A. specifications of 1889 would be a just and fair compromise. All the steel makers present assented to this so far as the phosphorus limit was concerned, which they said presented no difficulty. But they strenuously opposed reduction of the sulphur limit to .03 percent, alleging that since they were no longer able to use natural gas in all their processes the elimination of sulphur had become more difficult. The boiler men argued against this; that, first of all, a number of steel mills had been supplying A. B. M. A. steel under the 1889 specifications up to 1903, although they had never had the good fortune to have natural gas to use at any time; and, secondly, that a low percentage of sulphur was an absolute necessity in boiler plate, because of the well-known fact that sulphur makes steel red short, and therefore danger must always be apprehended if by any of the chances of service the boiler plate becomes overheated. The chairman of the A. B. M. A. committee further reported that in every case where boiler plate had cracked in service he had found, on chemical test of the failed plate, an excess of sulphur.

The compromise finally agreed on was to permit .04 percent sulphur and .06 percent phosphorus for acid, and .04 percent phosphorus in basic steel for flange and boiler steel, and .035 percent sulphur as well as phosphorus in fire-box steel and extra soft steel. The failure of the A. A. S. M. to ratify this unconditionally naturally caused a feeling of dissatisfaction in the A. B. M. A. It appears to them that questions of safety and uniformity have been subordinated to merely commercial considerations.

The A. B. M. A. being the originators in the United States of uniform specifications for boiler steel believe that they are entitled to more consideration than they have received. Having reluctantly withdrawn their more exacting specifications of 1898, and expressed their willingness to return to the chemical specifications of 1889, and, moreover, recalling the substantial agreement between them and the A. S. T. M., they naturally expect from this society a conservative movement for the preservation of the earlier very moderate standard.

Your committee R expressed the reasons for this in the report of June 10, 1908. In order to place the matter clearly before your committee we give here the present A. S. T. M. specifications and the 1889 specifications of the A. B. M. A.:

	Phosphorus		
	Acid.	Basic.	Sulphur.
A. S. T. M., flange or boiler steel...	.06	.04	.05
A. S. T. M., fire-box steel.........	.04	.03	.04
A. S. T. M., extra soft steel.......	.04	.04	.04
1889, A. B. M. A., all boiler steel..	.04 for bas. & acid		.03

We know no reason for allowing more phosphorus in acid than basic steel, nor any reason for allowing more phosphorus in extra soft than in fire-box steel. We believe that .04 for both basic and acid steel will be fair and not too severe, and yet be on the safe side.

As for sulphur we have not heard any tangible reason advanced why the limit of .03 percent, which was cheerfully acquiesced in by all the steel-plate mills making boiler plate from 1890 to 1902, should now be abandoned for a higher per centage in which there always lurks an element of danger. In considering this it must always be remembered that the segregation of the metalloids, as conclusively shown in the beautiful experiments of Mr. Charles M. Huston of some years ago, make it very probable that there will be spots in some of the plates where the sulphur runs higher than shown by the average mill tests,

Very respectfully submitted,

E. D. MEIER,
Chairman Committee R.

Exhibit "B."

NEW YORK, June 29, 1909.

The American Society of Testing Materials:

Your committee "R," on June 10, 1908, in a report on uniform boiler specifications, recommended that this society accept the joint specifications of the Association of American Steel Manufacturers and the American Boiler Manufacturers' Association of Dec. 22, 1905.

This report was signed by six of the members of the committee, but signature was refused by a minority of two. The majority represent builders and insurers of boilers and testing engineers, the minority are steel plate manufacturers.

The matter was finally referred to committee "A," which, under the circumstances, refused to change the specifications of the society.

As majority members of the committee who signed this report we deem it our duty to enter our respectful protest against this rejection of our recommendation.

The whole difference lies in the chemical requirements. We deem it unsafe to allow more than 0.04 percent phosphorus or more than 0.03 percent sulphur in boiler steel. These maximum limits were first fixed by the American Boiler Manufacturers' Association in October, 1889, and were generally acquiesced in by the steel plate manufacturers, and there never has been any difficulty in obtaining plate which will fill these specifications. They correspond with the requirements of the United States navy. During the twenty years since they were adopted much higher pressures and much greater capacity in evaporation have been demanded of boilers. It seems to us, therefore, unwise to reduce the requirements of the specifications for boiler plate.

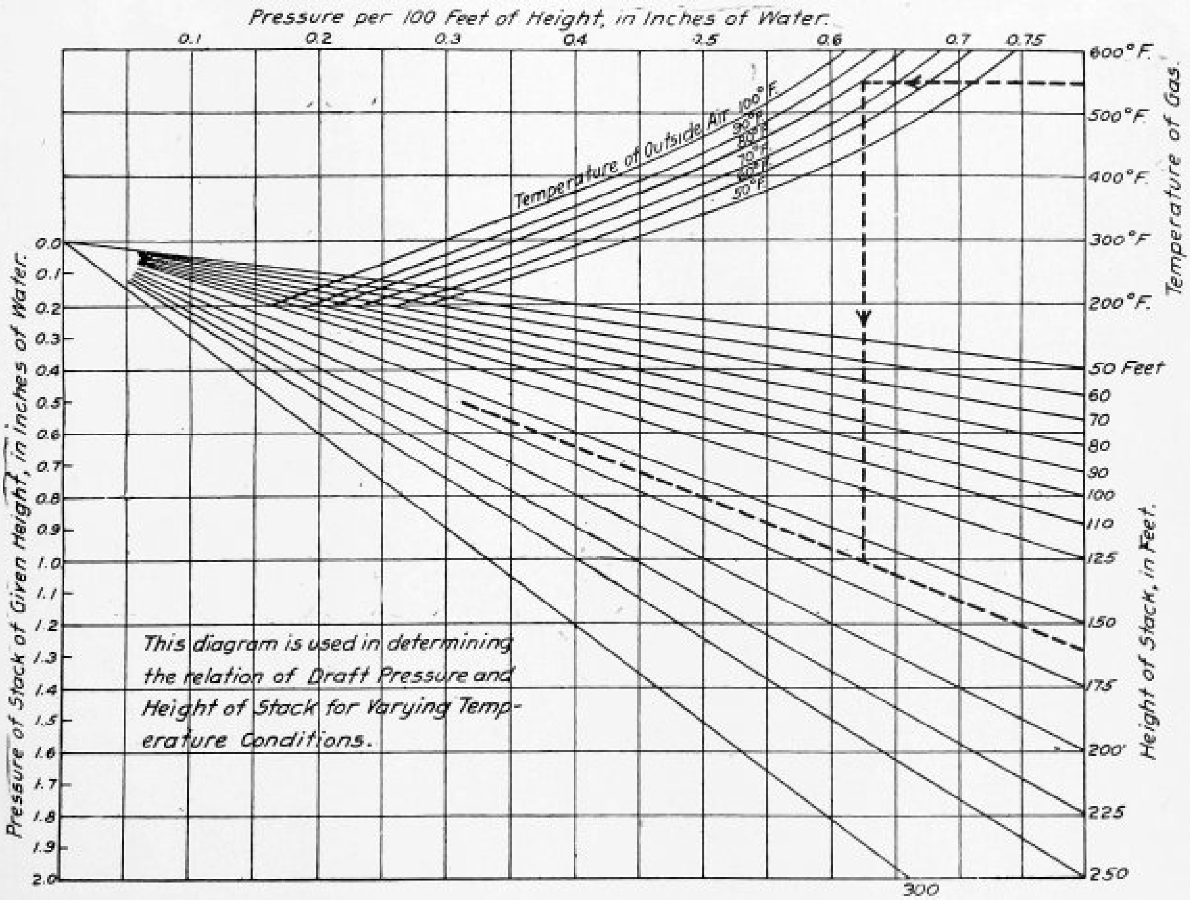
Very respectfully submitted,
E. D. MEIER, Chairman.

SIMPLE METHODS OF STACK DESIGN.

BY A. J. HAIRE, JR.

The engineer with a chimney or stack to erect, knowing the conditions he must meet with regard to boiler horsepower, draft, coal consumption, etc., usually turns to the hand-books, boiler makers' catalogues, and similar literature, rather than to one of the many exhaustive treatises we have on the subject of stack design. These catalogues and hand-books are often inadequate, treating the subject either so simply as to be incomplete, or so technically as to be practically useless. Matter that is found in one is often repeated in the others, and nine out of ten reproduce the familiar table that Kent worked out originally for his hand-book on mechanical engineering. All of these catalogues, however, are of some value, but nearly all fail in one respect or another to satisfy the needs of the busy engineer, who is not interested in learning the whole theory of the design, but wants definite information on how to build his stack with the conditions he has, so that it will work out as he wants it to after it is built. Ninety-nine times out of a hundred such an engineer decides on Kent's rule, and lets it go at that. Any values between those given in the table he disregards, and for any rate of coal combustion, or for any draft conditions other than those in the table, his percentage of errors is more or less great. He may overlook the fact that the values given by the table are based on a coal consumption of five pounds per hour, which is rather a high figure, and a figure that the average power plant should cut down materially, with even a fair grade of coal and boilers loaded economically. He may also overlook, and generally does, that the draft figured in reaching the values of the table is presumed to be the best, a state of affairs not always found in the average station. If he does not use this table, making allowances for the differences between his conditions and those for which the table was drawn, he has to resort to the literature on stack design, and make a lengthy computation, and the chances for error will be twice as great as if he used the table.

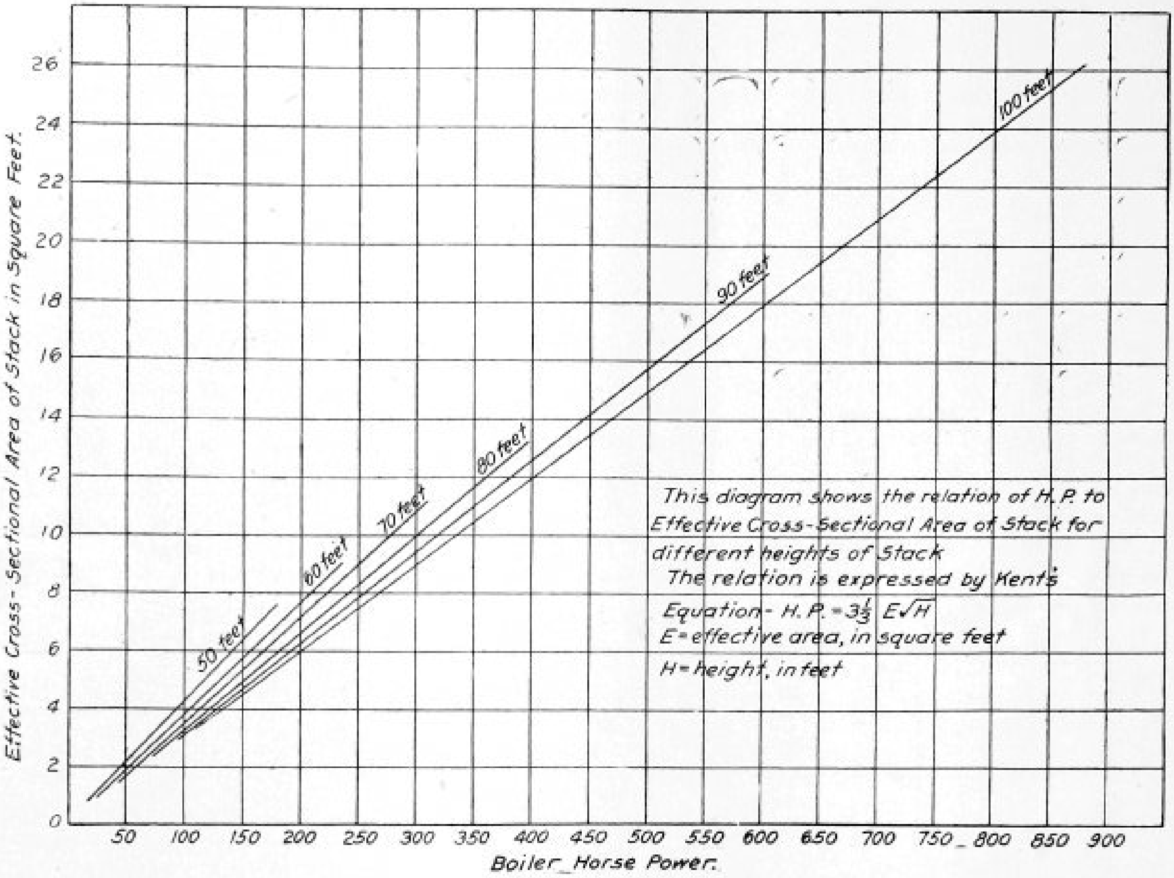
The diagrams shown herewith represent the medium between relying solely on a table drawn up for an arbitrary set of conditions and making a separate design with great waste of time and possibility of error for each stack. Exact results can be obtained from them with ease and quickness. Every element that would come in any computation is met in these diagrams, as a glance will show, and there is absolutely no guesswork in any decision, no necessity for interpolation of values as in the case of the table, and no need of using constants to correct the final answer to suit your own case.



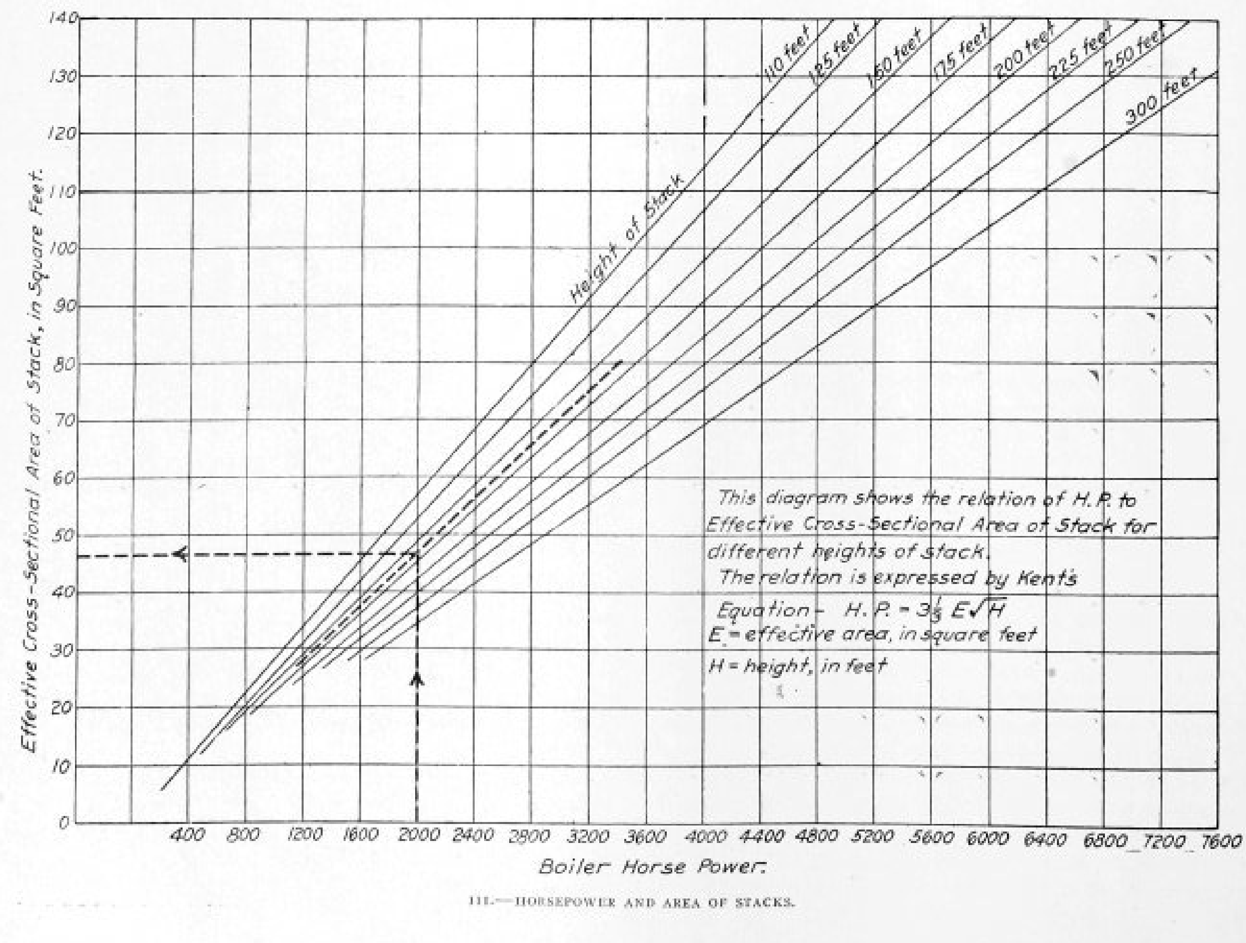
1.—DRAFT PRESSURE OF STACKS FOR TEMPERATURE AND HEIGHTS.

USE OF THE DIAGRAMS.

Diagram No. 1 gives a double set of curves, which are plotted between temperatures of flue gas, or inside and outside air, with varying heights of stacks, and the draft pressure in inches of water. By it we can determine the relation of



II.—HORSEPOWER AND AREA OF STACKS.



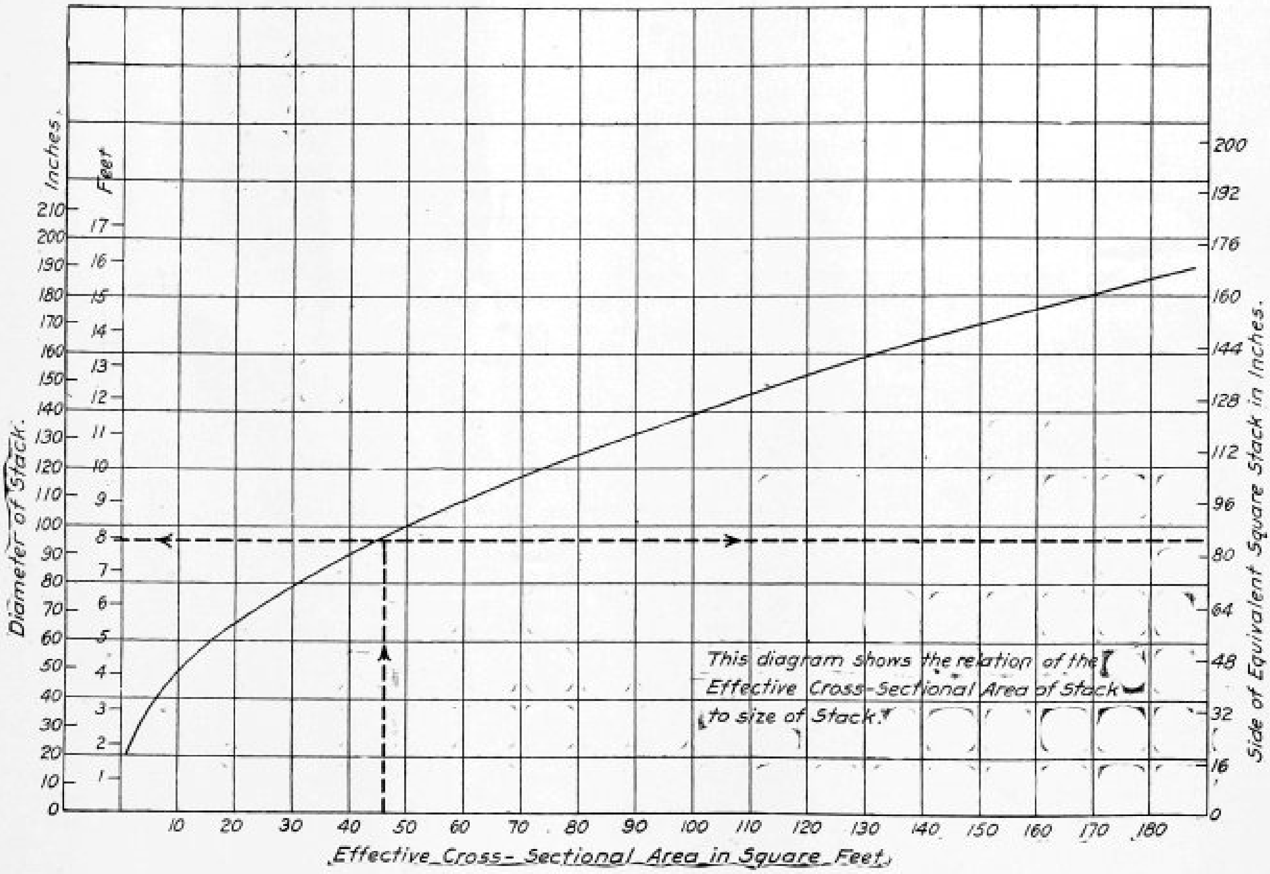
III.—HORSEPOWER AND AREA OF STACKS.

the height to the draft pressure desired with the different temperature changes. This diagram can also be used in determining the draft if we know the height of the stack and the temperatures of the inside and outside air.

Diagrams Nos. II. and III. show the relation between the height of stack, the amount of boiler horsepower, and the cross-sectional area. Diagram No. II. provides for boiler horsepower up to 850, and No. III. for values beyond that. Knowing the height, from diagram No. I., and knowing the horsepower, we use these curves to get the effective cross-sectional area necessary for the stack.

7 feet square. Hence, from the curves we have a stack 160 feet high, effective cross-sectional area of 47 square feet, and either 8 feet in diameter or 7 feet square.

These curves have been carefully worked out, and are exact. They are now in use by some of the largest engineering concerns in New York, and several universities have adopted them in their courses of instruction for power-station work. The engineer who gives them a fair trial will undoubtedly find them of great value and superior to all general tables or arbitrary rules in the current literature or catalogues of the day.—*Machinery.*



IV.—EFFECTIVE AREA AND SIZE OF STACKS.

Diagram No. IV. makes it possible to determine at a glance the side of square stack having the necessary cross-sectional area, or the corresponding diameter of a round stack.

For example, we will design a stack for 2,000 boiler horsepower, stack temperature to be 550 degrees F., and outside temperature 80 degrees F., the maximum summer temperature. The pressure on the stack is to be 1-inch pressure of water. From diagram No. I., starting at 550 degrees F. at the right of the sheet, run over to the curve representing 80 degrees F., temperature of outside air. From this point drop down to the horizontal line representing 1-inch pressure for the desired stack, in inches of water. The point found here gives us 160 feet for the stack height. Refer to diagram No. III. to find the cross-sectional area, since the boiler horsepower equals 2,000. Where the vertical line at 2,000 boiler horsepower crosses the line of the 160-foot stack, we get a point which, projected to the left of the sheet, gives a cross-sectional area of about 47 square feet. From diagram No. IV. we find that value of 47 square feet cross-sectional area on the curve, and running to the left we get the diameter of the stack corresponding to that area, which is 96 inches, or 8 feet. The side of the square stack with corresponding area as shown to the right of the diagram would be slightly less than

The National Association of State and Municipal Boiler Inspection Departments.

Delegates from the State and municipal boiler inspection departments of Detroit, Mich.; Nashville, Tenn.; Providence, R. I.; Omaha, Neb.; Los Angeles, Cal.; Denver, Col., and Minneapolis, Minn., met in Detroit, Mich., Aug. 10, 11 and 12, and perfected an organization to be known as the National Association of State and Municipal Boiler Inspection Departments. The primary object of this organization is to promote uniform inspection methods and boiler construction as well as to facilitate the exchange of ideas and experiences, and the movement has the hearty approval of the American Boiler Manufacturers' Association. It will be the aim of the organization to meet annually to promote the growth of the organization and extension of uniform practice in inspection and construction.

The officers chosen are as follows: J. C. McCabe, Detroit, president; Charles E. Doyle, Providence, R. I., first vice-president; Phil. McCarty, Denver, Col., second vice-president; M. J. Close, Minneapolis, Minn., third vice-president; M. N. Brien, Nashville, secretary; Robert Wolfe, Omaha, Neb., treasurer; F. E. Griesmer, Los Angeles, chairman committee on rules.

It is a matter of notoriety that in the past, with few exceptions, municipal boiler inspection departments throughout the country have been exceedingly inefficient. The stimulus of this movement will undoubtedly do much to promote public safety and uniformity.

LAYOUT OF THE SLOPE SHEET OF A LOCOMOTIVE BOILER.

BY A. E. CLEMENTS.

In the type of locomotive boiler shown in the side and end elevation, Fig. 1, there are two styles of slope sheets that may be applied. The first and most common is that shown by the dotted lines in the side elevation; the second is that shown by the solid curved line in the same view. The latter has two advantages over the first, since, by cutting it in a circle as shown, it does away with the longitudinal seam, and also cuts out considerable of the flat surface shown by the triangle *a, b, c*. The pattern for either of these sheets is layed out in the same manner, so only the second sheet is shown.

First, draw the side and end elevations, and divide the quarter circle into any number of equal spaces (in this case three, numbered from 0 to 4) and project these points to the side elevation, extending the lines through the slope sheet parallel to the line *d e*. In order to obtain the stretch-out for the pattern, it is first necessary to construct a section at right angles to *d e*, as shown by Fig. 1. This is constructed as follows: First, draw the line *b f* through the slope sheet, continuing it above the outline of the boiler; transfer the spaces on *b f* from *f* to *g* to the line *f'-g'*, Fig. 1, and draw lines at right angles to *f'-g'* from the points thus located. On these lines set off the distances taken from the vertical center line of the end elevation to points 1-2, etc., trace a line through these points, completing the section.

The spaces on this curved line are now transferred to the stretch-out line *b"-f"*, Fig. 2. Draw lines at right angles through the points thus located, and number as shown. Now set the dividers to the distance *f* to *d* of the side elevation and transfer this to the pattern on line *o"*. Continue this procedure until point 4 is reached; then set the dividers from 4 *c* to *b*, and transfer to *c'-b"*, Fig. 2; transfer the distances from *f-g* to the curved outline *b-e* in the same manner. A line traced through the points thus located will form one-half of the pattern. All points in the patterns have been lettered similar to the points in the side elevation.

This sheet is often spoken of as the taper course of the boiler, but by a careful study of the two views it will be seen that it has no taper at all, but is a section of a cylinder set at an angle to the center line of the boiler.

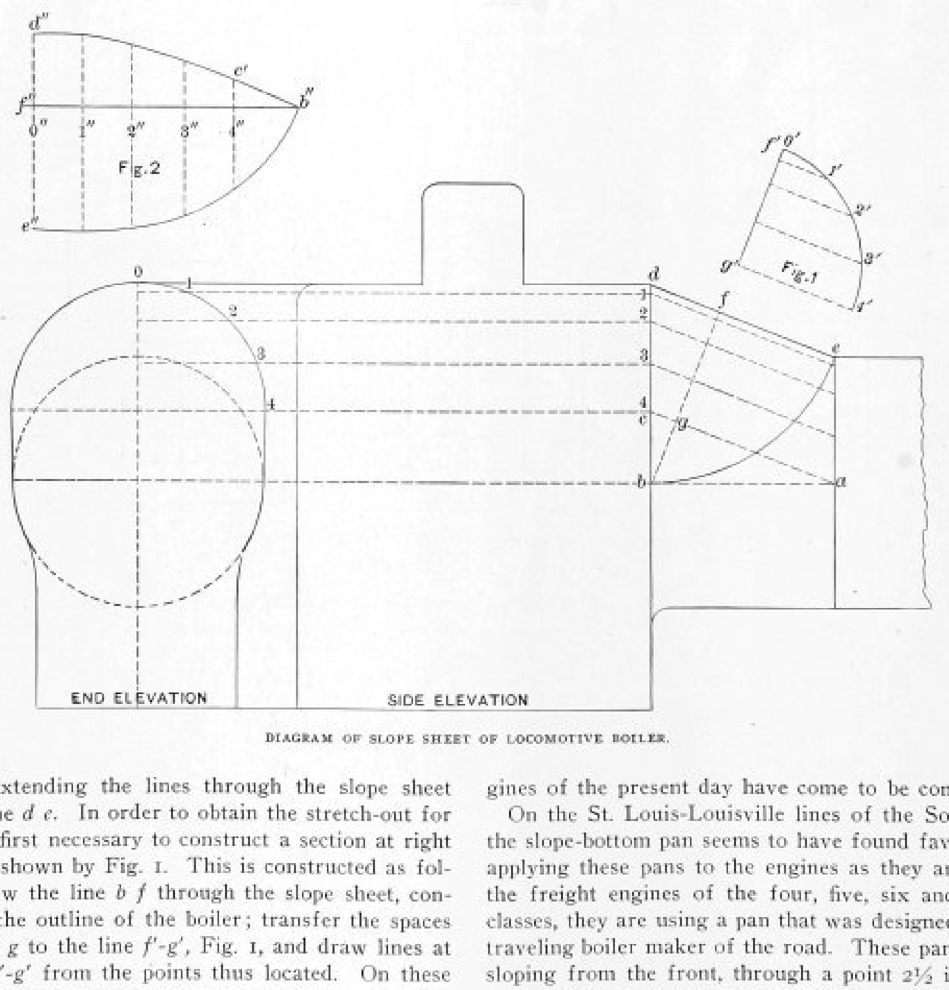


DIAGRAM OF SLOPE SHEET OF LOCOMOTIVE BOILER.

SELF-DUMPING ASH PANS ON THE SOUTHERN R. R.

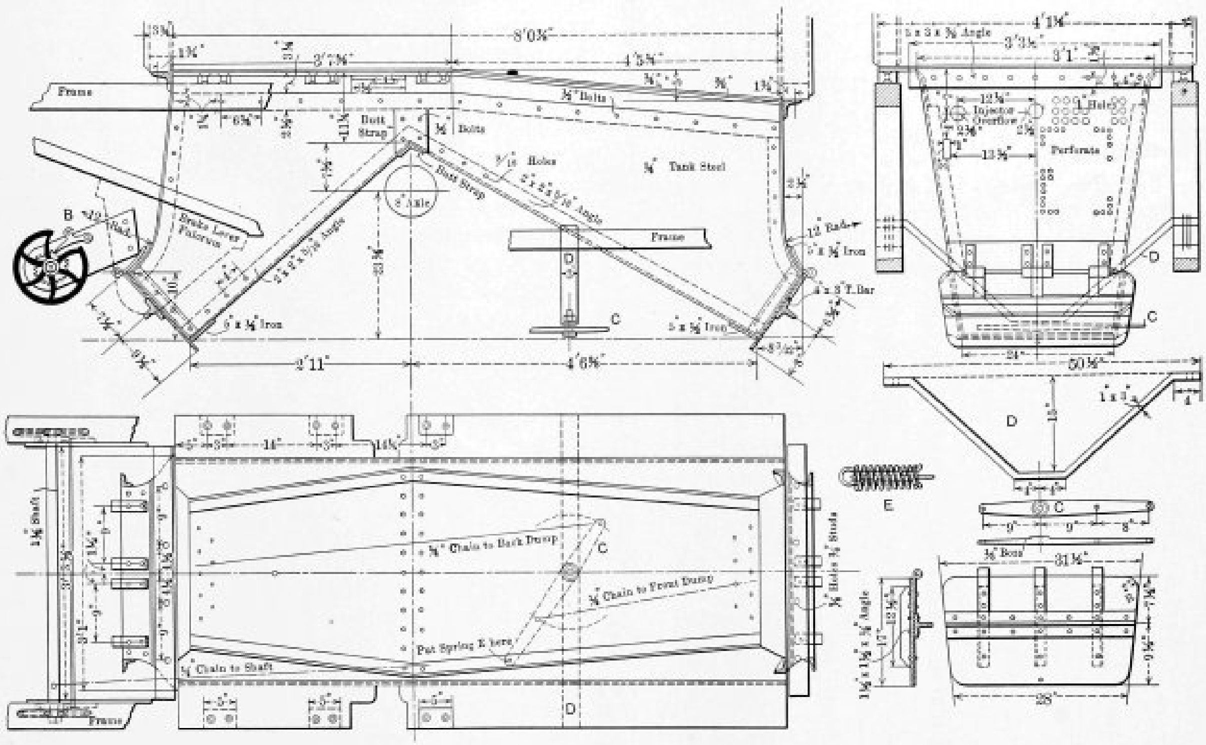
BY WERNER G. VOGEL.

Since the enactment of the law requiring locomotives to be equipped with self-cleaning ash pans, railroad men, and especially the boiler makers, have been thinking about and designing pans that would comply with the law. Many different styles have been the result, and for each style some special claims are made. Some roads prefer one style and some another; the particular kind usually being decided on by the master mechanic or foreman, who chooses for cheapness, ease of application and simplicity. At best, ash pans for the engines of the present day have come to be complicated affairs.

On the St. Louis-Louisville lines of the Southern Railway, the slope-bottom pan seems to have found favor, and they are applying these pans to the engines as they are shopped. On the freight engines of the four, five, six and eight hundred classes, they are using a pan that was designed by Mr. Mayer, traveling boiler maker of the road. These pans have a bottom sloping from the front, through a point 2½ inches above the center of the axle to the back. Both overflow pipes from the injectors enter near the front of the pan and wash the ashes down the inclined bottom and out the damper or door at the back. The damper can be easily operated from either side of the engine. On one engine it is so arranged that it can be operated by a lift in the cab.

This style of pan could not be applied to the passenger engines of the nine and ten hundred classes on account of the axle being higher than on the freight engines, so making the pan too shallow. It was then decided to try a pan with the bottom sloping both to front and back from a point 3 inches above the center of the axle. This resulted in the writer designing the pan shown in the accompanying sketch.

The pan is made of 1/4 inch tank steel and 2 inches by 2 inches by 5/16 inch angles. The wings to which the pan is hung are of 3/8 inch material. These wings are the only part of the old pan used on the new. The doors are of 1/2 inch material, stiffened by three pieces of 1 1/2 inches by 1 1/2 inches by 1/4 inch angles on the inside, and a piece of 4 inches by 3 inches T-bar outside. Across the back and front and across both bottoms, where the floors fit, are pieces of 5 inches by 1/2-inch bar iron, and on each side pieces of 2 inches by 2 inches



ASH PAN FOR TEN-WHEEL PASSENGER ENGINE, SOUTHERN RAILWAY.

by 5/16-inch angle iron. For reinforcing, this may seem to some to be overdone, but it was done to prevent warping, and, so far, has proved a success, as the engine (915) has been in service one month now and has not warped.

The overflow pipes from the injectors enter at the front and back of the pans. Water from these puts out any fire that is in the pans, and also helps to wash out the ashes when the doors are opened. The doors are very heavy and swing open by gravity when released. They are closed by a very simple lever and chain arrangement under the pan.

An offset bar (*D*) is fastened to the frame at any convenient place under the pan. To this is bolted a lever (*C*), which is 29 inches long, having four holes in it, spaced 9 inches by 9 inches by 8 inches from center to center. One hole is used to bolt the lever to the bar (*D*). From the other holes, chains are run to the front and back doors, and also to the shaft that crosses from frame to frame behind the pan.

This shaft is held in place by two pieces of 1/2-inch iron or boiler plate, say 8 to 10 inches wide, bolted to the brake-lever fulcrums. A ratchet and brake wheel, such as are used on freight cars, is applied to each end of the shaft.

The drags (*B*) are connected by a small rod, so that both can be lifted at once from either side of the engine.

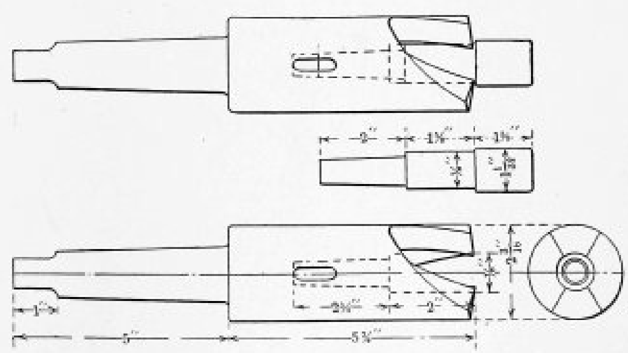
Fig. *E* in the drawing is a 2-inch spiral spring of 3/8 inch material, which is put into the chain that connects the lever to the shaft. When the doors are closed, a strain is put on this spring and the drags (*B*) held firmly in place. This guards against any slipping, thus letting the doors come open.

So far it is claimed that this style of pan has proved a success in every way.

Flue-Hole Cutter or Counterbore.

A special tool for the drill press, used in cutting the flue holes in the flue sheets of boilers, is shown in the engraving This tool is of tool steel and is made the size of the flue hole. The center hole is bored and tapered to fit a Morse No. 2 taper, and the center piece or guide shown, which is also of tool steel, is then turned and fitted. The jaws are next milled, and then both the tool and the center guide are hardened and ground to the exact size, clearance being given to the cutting edges.

The flue sheets to be drilled are first laid off, centered, and 1-inch holes punched. They are then taken to a radial drill press and the holes are reamed out with a 1 1/16-inch drill, which takes only a short time and leaves a clean, round hole for the center guide to work in. The tool illustrated here-



DETAILS OF FLUE HOLE CUTTER.

with is then put in the drill-press and used as a drill, the center guide being placed in the holes already made. The center guide pin is made removable, so that the edges of the cutter can be ground easily, and also extends over the inner edge of the cutters, which makes the tool work very evenly. This cutter has been used in the D. & I. R. shops at Two Harbors, Minn., and its work is satisfactory.

AUSTIN G. JOHNSON, in *Machinery*.

Problems Connected with the Layout of a Locomotive Boiler.

BY JOHN COOK.

In laying out a locomotive boiler, it is always best to draw a diagram of the front head and lay out all the points necessary for its construction. This, of course, must be made full size, both front and side views. For the side, use a board 14 or 16 inches wide and 16 feet long, smoothed and chalked nicely, so that a pencil mark will be seen plainly. When laying this out, first draw the base line *A B* (Fig. 1), and erect the perpendicular line *C D*. Now, as this is to be a 42-inch diameter boiler, and one-third of 42 is 14 inches, we will allow 14 inches from the bottom of the fire-box to the bottom of the shell of the circular part, or barrel. This will be the depth of the throat sheet. With the trams set 21 inches between centers, set one point on the point *J*, and strike the center and draw the circle as shown. Also draw a circle outside of the last, one-half the thickness of the metal, to be used for the measurements taken on all curves.

The left of Fig. 1 shows the layout of stay-bolts, tubes and braces on the tube sheet, and throat sheet, the right side shows the layout of stay-bolts and braces and door on the back head.

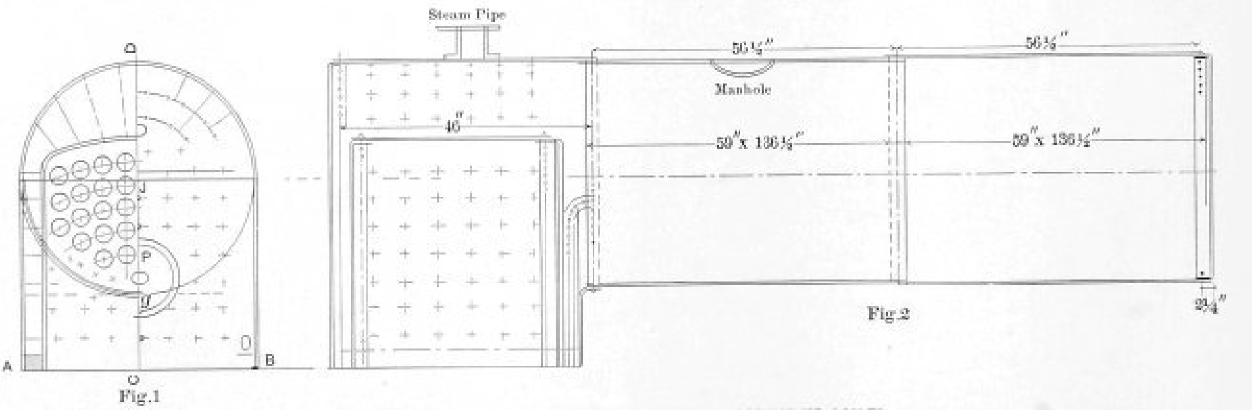
The top of the fire-box can be crowned or left straight, but I think it is better to have it crowned. The fire-box will be 42 inches high, then by setting the trams 42 inches wide, putting one point on point *C* on line *C-D*, the arc can be drawn as shown. Since there is a 3-inch water space all around, the fire-box will be 36 inches wide. Lay off 18 inches on each side of center line *C-D* and draw the side of fire-box. This line will be the outside of fire-box sheet. Lay off 3 inches from these lines and draw lines cutting the 42-inch circle. These will be the inside of the wagon-top sheets. The measurements can be taken on either the inside or outside of the thickness of the sheets on straight work. To make it easy to bend the sheets, the corners of the fire-box crown and the fire-box heads should be made to a 3-inch radius.

To get the points for the stay-bolts, start from the center line *C-D* with the dividers spread so that they will not space over 5 inches. In this case there will be a half stay-bolt space each side of the center line, the space being 4½ inches. Leaving 2¼ inches from the center line, the other three spaces 4½ inches by measuring from lower break line on the corner to the center of the bottom holes in the frame, we can get seven rows 5 inches between centers. We will draw lines with a square laid on these points, cutting the sides of the wagon-top sheets. We will have to find a center that will give pretty nearly full threads on the wagon top, as well as on the crown of the fire-box, in this case at *P*, 25½ inches from the top of the crown sheet on line *C-D*. By laying a straight edge on point *P*, cutting the points on the crown sheet, draw lines cutting the wagon-top sheet.

On the right side of Fig. 1 is shown the layout for stay-bolts on the head, also for the braces, hand holes and fire door. As will be seen, the centers for stay-bolts are spaced about 5 inches. The brace holes are spaced so as not to interfere with the stay-bolts on the crown. There will be eight braces, five in the top row and three on the lower. These arcs will be struck from the center of the boiler.

The side view, Fig. 2, will explain itself. In showing the layout of stay-bolts, as seen in Fig. 1, the stay-bolts are 5-inch centers perpendicularly, and on Fig. 2 they are 6-inch centers, the fire-box being 38 inches long inside, the end rows being 6-inch centers, horizontally, from the rivet holes in the flanges of the outside front head and throat sheet.

The sheets required for this boiler will be fire-box sheet 38 inches by 112 inches by 5/16 inch, wagon-top sheet 48½ inches by 113 inches by 5/16 inch, the back head will be 47 inches by 58½ inches by ⅜ inch (this is allowing 2½ inches for flange), throat sheet 47 inches by 32 inches by ⅜ inch, fire-box heads 40 inches by 44½ inches by ⅜ inch.



LONGITUDINAL AND TRANSVERSE SECTIONS OF LOCOMOTIVE BOILER.

Now let us see how we are going to come out on this. The fire-box being 36 inches by 36 inches, we have 9 square feet of grate surface, and it is usual to allow from 30 to 36 square feet of heating surface to one of grate. We will calculate on 36 square feet. Then by multiplying 36 by 9 we get 324 square feet. Now, in the fire-box sheet (38 inches by 112 inches), deducting 12 inches from the length, leaving it 38 inches by 100 inches, we have $3{,}800 \div 144 = 26.38$ square feet heating surface. The fire-box backhead being 42 inches by 36 inches, we will take 6 inches from each head (the grates being above the bottom), leaving 36 inches by 36 inches $= 1{,}296$ square inches. Now the area of door must be taken from that, the door being 12 inches. The area is therefore 113 square inches, and 113 subtracted from $1{,}296 = 1{,}183$; $1{,}183 \div 144 = 8.35$ square feet. The tube sheet will have 1,296 square inches less the area of the tubes, the area of one 3-inch tube is 7.0686 square inches, and there are thirty-four of them, therefore $7.0686 \times 34 = 240.3324$ square inches; 240.33 taken from 1,296 leaves 1,055.67 square inches, or 7.331 square feet. Now the front tube sheet is 42 inches in diameter, the area of which is 1,385 less the area of tubes. As we found there were 240 square inches in thirty-four tubes 3 inches diameter, then 240 from 1,385 leaves 1,145 and 1,145 ÷ 144 = 7.95 square feet in the front tube sheet. Thus, to sum up:

26.38 square feet in the fire-box sheet,
8.35 square feet in the back fire-box head,
7.33 square feet in the fire-box tube head,
7.95 square feet in the front tube sheet.

50.01 or 50 feet.

This leaves 274 square feet to be made up through the tubes. The circumference of a 3-inch tube would be 3.14 × 3 = 9.42, and 9.42 × 12 inches (length) = 113.04 square inches; 113.04 × 34 (the number of tubes), equals 3,843.36 square inches, or 26.62 square feet; 274 divided by 26.62 equals 10; so the tubes will be 10 feet long.

Now to find the strength we will first take the stay-bolts. They are spaced 5 inches by 6 inches. Therefore each bolt supports an area of 30 square inches. Good stay-bolt iron has a tensile strength of 50,000 pounds per square inches; the area of a ⅞-inch stay-bolt at the bottom of the thread is .4617, which, multiplied by 50,000 = 2,308.50 pounds, and 2,308.50 ÷ 6 (factor of safety) = 3,846 pounds, safe strength, of each bolt. Now as we want to carry 120 pounds steam pressure on this, we will divide 3,846 by 120 = 32.05 square inches (the area one stay-bolt will support). The bolts are therefore amply strong, since they have to support only 30 square inches. Another rule gives us but 93 pounds allowable pressure. That is to multiply the constant 112 by the square of the thickness of metal in 16th; thus, the square of 5 is 25; then 112 × 25 = 2,800, and 2,800 ÷ 30 = 93 pounds. This last rule gives a pretty low pressure, but it is safe. I have seen ¾-inch bolts spaced 6-inch centers, and no one could tell what pressure was on, for there was about 100 pounds of scrap iron hung on the end of the valve lever and still blowing off. The metal was ¼-inch iron, *not steel*. As the last rule is the Government rule we will let it go and get the laps.

The girth seams will be single-riveted ¾-inch rivets 2⅛-inch centers. Horizontal seams double lap-riveted the spacing on a single row 2⅞ inches, and the center line of the next row 1⅝ inches. My practice is to set the dividers to the same space as on the girth seam, and strike arcs, cutting each other on the next row. This gives 70 percent efficiency of joint, and an allowable pressure of 125 pounds, but as the straight sides of fire-box are the weakest point, we must go by that, so 93 pounds per square inch will be the safe working pressure.

A Proposed Expansion Buckle to Relieve the Expansion and Contraction Stresses on the Side Sheets of High-Pressure Boilers.

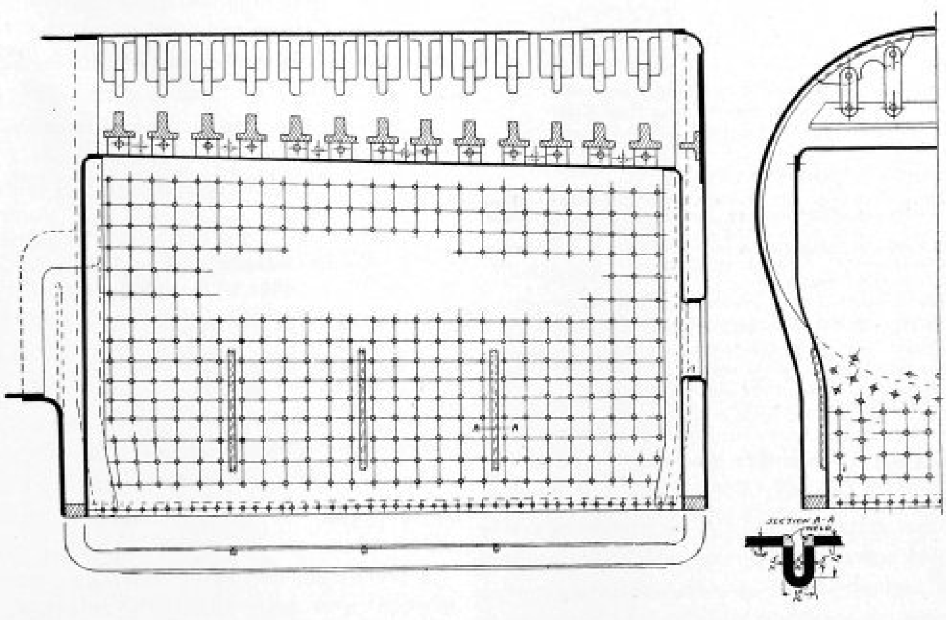
BY R. W. CLARK, FOREMAN BOILER MAKER, N. C. & ST. L. RAILWAY.

As shown in the illustration, divide the side sheet into three or four parts, according to the length of the fire-box. In a 9-foot fire-box the writer would advise using three buckles to be sure of getting sufficient elasticity to relieve all the stresses that may come on the side sheets due to expansion and contraction.

Three slots are marked off in the side sheet, as shown in the sketch, each slot being 15/16 inch by 24 or 30 inches, according to the depth of the fire-box. These slots are then cut out with an oxy-acetylene blow-pipe. Then bend a piece of 5/16-inch fire-box steel in the shape of a U. After bending have the blacksmiths weld up both ends. Place this U-buckle into the slot, which has been cut in the side sheet, and fasten it in place by using a couple of small steel wedges at the top and bottom, just tight enough to hold it in position. Then take the oxy-acetylene welding flame and proceed to weld the U-piece in position.

This can be accomplished at very slight cost, and the writer claims that the use of these expansion buckles will stop the leaking of stay-bolts above the grate bars, and will also relieve the stresses on the side sheets, which cause the sheets to crack through the stay-bolt holes. These cracks have been a constant source of annoyance, and they are due solely to the unequal expansion and contraction of the side sheet.

While this construction has not as yet been applied to a boiler yet tests have been made on the buckles, and it has been found that there is no movement in the weld, all the movement being in the buckle itself, so that whatever brittleness there might be in the weld would not be likely to cause a fracture in the weld. The actual movement in the buckle is, moreover, so slight that it would be impossible for it to cause a fracture.



LOCOMOTIVE FIRE-BOX, SHOWING LOCATION AND FORM OF EXPANSION BUCKLES.

The Boiler Maker

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CIRCULATION STATEMENT.

Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

English Locomotive Boilers.

Locomotives on the Lancashire & Yorkshire Railway have become fairly well standardized and may be considered representative of English practice. The notes which Mr. Hughes, chief mechanical engineer of the railway, presented recently before the Institution of Mechanical Engineers regarding these boilers are therefore of interest as indicating the general trend of English locomotive boiler practice. One of the most noticeable things about English locomotive boiler practice is the extensive use of copper for fire-boxes and tubes. Results seem to show that copper tubes, whether new or safe-ended, last from 40 to 50 percent longer than steel tubes; copper fire-boxes average from 150,000 to 275,000 miles, and copper tube plates last from three and one-half to seven years. These results are obtained with narrow fire-box boilers with large water spaces. The decreased grate area resulting from the use of wide water spaces has not impaired the steaming qualities of the engines, and has resulted in increased mileage and fewer repairs, particularly in the renewal of stays.

Extensive experiments on front-end arrangements have led Mr. Hughes to conclude that it is impractical to standardize smoke-boxes, as has been advocated in the United States. Although this practice has met with some success in America, yet he maintains that each new design of locomotive demands some experimental work in order to arrive at the best steaming position of nozzle, diameter of stack, etc. His experiments have included tests to determine the value of long and short smoke-boxes, the heights and lengths of hoods and blast pipes in relation to the tubes, and the effect of varying the position of the center line of the blast pipe in relation to the front tube plate. As far as long and short smoke-boxes are concerned the advantage, as might be expected, lies with the long box, since it acts in the nature of a reservoir, maintaining a more steady vacuum, and consequently maintaining the steam pressure better. Since there are so many variable factors influencing the position and size of blast pipes, hoods and stack relative to the tubes, factors which depend not only on the design of the locomotive but on the conditions of service, which, in themselves, are extremely varied, there seems to be no way to determine these quantities satisfactorily other than by experiment in each individual case. The position of the center line of the blast pipe in respect to the smoke-box tube plate Mr. Hughes found to be not so serious a matter, for although a more even draft was obtained when the blast pipe was located about midway between the door and the tube plate, yet if it is convenient to locate the blast pipe elsewhere no serious results are likely to ensue.

One thing that was emphasized strongly was the fact that brick arches are used in all the locomotives, and that they are a necessity for the successful operation of the locomotive.

Commendable Action Taken by the Boiler Manufacturers.

The American Boiler Manufacturers' Association, at its recent convention in Detroit, voted to revert to its original specifications as regards phosphorus and sulphur in boiler plate. These specifications, which were originally adopted in 1889, limit the phosphorus to .04 percent and the sulphur to .03 percent, and are virtually the same as those adopted by the United States Navy. It has frequently been shown that these specifications are not unduly stringent; yet they have been continually opposed by the steel plate manufacturers. Concessions were made to the steel manufacturers by the boiler manufacturers in 1898 and again in 1905, when a compromise was effected by committees representing the opposing interests, which, however, subsequently failed of ratification by the American Steel Manufacturers' Association. The boiler manufacturers are therefore amply justified in insisting on their original demands, and it is to be hoped that before long these specifications will become the basis for the general trade, since they represent the best practice in modern boiler construction.

The Design of Steel Stacks.

Those boiler makers and layers-out who are confronted with the problem of building a steel stack to meet certain conditions, will find some valuable information on this subject in two articles which we publish this month. One of these gives a series of diagrams whereby the dimensions of the stack can be ascertained for any given requirements of boiler horsepower, draft, coal consumption, etc., and the other gives the detailed calculations which must be made to determine the strength and stability of the stack. A thorough understanding of these two articles will suffice to solve most problems in steel-stack design.

TECHNICAL PUBLICATION.

Tables and Diagrams of the Thermal Properties of Saturated and Superheated Steam. By Lionel S. Marks, M. M. E., and Harvey N. Davis, Ph. D. Size, 6½ by 9 inches. Pages, 106. Figures 8. New York, 1909: Longmans, Green & Company. Price, $1.00 net.

Recent investigations by Dieterici, Griffiths, Henning and Joly give a trustworthy set of new values for the total heat of dry steam at pressures below atmospheric pressure, while the method recently elaborated by Dr. Davis, when applied to the throttling experiments of Grindley, Peake and Griessman, give remarkably accordant determinations at pressures above atmospheric pressure. The steam tables have, therefore, been recomputed, based upon these new properties, that are probably correct to one-tenth of 1 percent within the range of steam pressures usual in engineering practice. Supplementary tables extend the superheated steam table to very high temperatures and give the properties of water, metric conversion factors, Naperian logarithms and other quantities. Two large supplementary diagrams are also provided, which can be used instead of the tables if it is desired to facilitate certain computations.

The McGraw-Hill Book Department.

The announcement is made that the book departments of the Hill Publishing Company and McGraw Publishing Company have been consolidated under the name of the McGraw-Hill Book Department, at 239 West Thirty-ninth street, New York. The new company has taken over all the books issued by both companies, embracing 250 titles, including works on electricity, mining, metallurgy, machinery and civil and mechanical engineering. The officers of the new company are: John A. Hill, president; James H. McGraw, vice-president; Edward Caldwell, treasurer, and Martin M. Foss, secretary.

PERSONAL.

P. S. HURSH, general boiler inspector of the New York, New Haven & Hartford Railroad Company, has taken a position as foreman boiler maker of the Buffalo, Rochester & Pittsburg Railroad, at Dubois, Pa.

J. T. GOODWIN, formerly foreman boiler maker of the Richmond Works of the American Locomotive Company, on Sept. 1 will assume the duties of mechanical expert with the National Tube Company, with headquarters at their New York office.

OSCAR HOLLOWAY died recently from heart failure in San Bernardino, Cal. He was born in England in 1848, but had lived during his entire life in America. He was a well-known boiler maker in many of the Western States, particularly on the Pacific Coast.

THOMAS H. SEARS, president and treasurer of the Holyoke Steam Boiler Works, Holyoke, Mass., died July 30, aged 56 years. A native of Ireland, he came to this country as a boy, and at the age of 13 went to work at Hartford, Conn., as a rivet driver in a boiler shop. After experience in boiler works in various New England cities, he went to Holyoke in 1871, and entered the employ of Coughlin & Mullen, and became foreman, then superintendent and finally manager, which position he held in 1902, when the business was incorporated as the Holyoke Steam Boiler Works.

COMMUNICATION.

Anent State Boiler Inspection Laws.

EDITOR THE BOILER MAKER:

State boiler inspection laws ought to be passed and put in force in the oil field region, since in this region they really do not take time to put up a boiler in a safe manner, and after it is up they neglect taking proper care of it. I have seen a couple of blow-outs near our location which would have caused great destruction if the boilers had been used a long time and become crystallized.

Fortunately they were new boilers. One of them had about two barrels of water in it. The engineer got on top to screw down the safety valve, as it made steam too fast. He had just got down on the floor when it let go. There was a hole torn in the bottom 18 inches wide and 7 feet long, yet the boiler stayed on its setting. It was a 60-horsepower boiler, built of 5/16 inch metal, 60,000 pounds tensile strength. All that saved it was the fact that the metal elongated over 75 percent before fracturing. No one was hurt.

The other boiler was a small blow-out, caused by working the boiler too far above its capacity, having a pier in front of the blow-off to cause a double action of heat. The evaporation was too rapid, causing a steam pocket, so that when water came back it came down.

Another one was affected on all parts wherever the heat from the furnace reached it. The engineer was supposed to be all right, but proved to be ignorant. He tried to fill the lubricators without blowing out the condensation. The oil overflowed. In order to be sure and get oil in the valves, he opened up the back manhead on the boiler, which was a 50-horsepower, horizontal, tubular boiler, and put in five gallons of cylinder oil. In a few hours he could not keep water in the boiler. He called me up. I went to examine the boiler and told him there must be oil in the boiler. He said "no." When I ordered the manhead out he left, and we did not see him again. There was plenty of oil in the boiler, however, as it took two boiler makers and a helper three days to renew the loose rivets. The braces were also all renewed.

From this the danger of not caring for new boilers is apparent. On the other hand, there are many cheap plants put up in a haphazard way, by buying second-hand boilers that look good, after being in service twenty-five years, but are really badly crystallized. All these boilers should be tested to detect the quality of the material, and any boiler having been condemned should be so stamped on each sheet, and a fine of $500 imposed on anyone attempting to use it again as a steam boiler or vessel to carry any pressure.

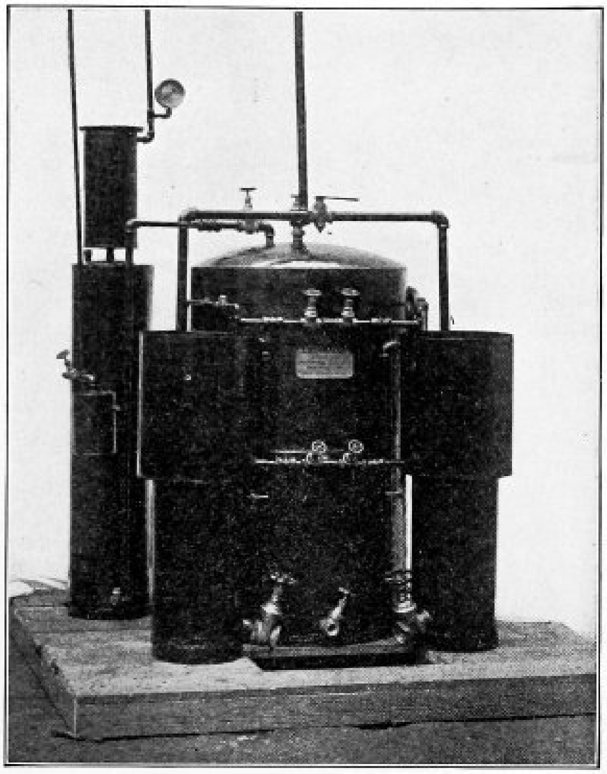
JOE HOLLOWAY.

ENGINEERING SPECIALTIES.

The Kimball Acetylene Gas Generator.

A continuous-generation, variable-pressure, acetylene generator for oxy-acetylene welding apparatus is manufactured by the Oxy-Carbi Company, 516 Orchard street, New Haven Conn., known as the Kimball generator. The general arrangement of the apparatus is shown in the illustration. The large tank is for gas storage and water supply to the carbide, the water level being maintained by the ball-float valve on the water inlet from any source where a suitable pressure equal to that desired on the gas may be obtained. The carbide holders are connected to this tank by the water-feed and the gas-discharge tanks and also by the small gas relief pipes. If gas should be generated in the holders with the valves accidentally closed it may escape into the gas chamber.

In operation the carbide is passed into one of the holders through a hand-hole in the top. It rests on a grate of peculiar construction, which it is claimed admits of perfect generation without clogging or burning. By opening the water and gas valves to the holder the water is allowed to act on the carbide. As the gas generates to a certain pressure the water is forced back from the carbide, causing generation to cease unless the gas is used, in which case it will continue generation to any amount called for until the carbide is exhausted or the consumption is stopped. Excessive, or after generation, forces the water out of the supply tank and away from the



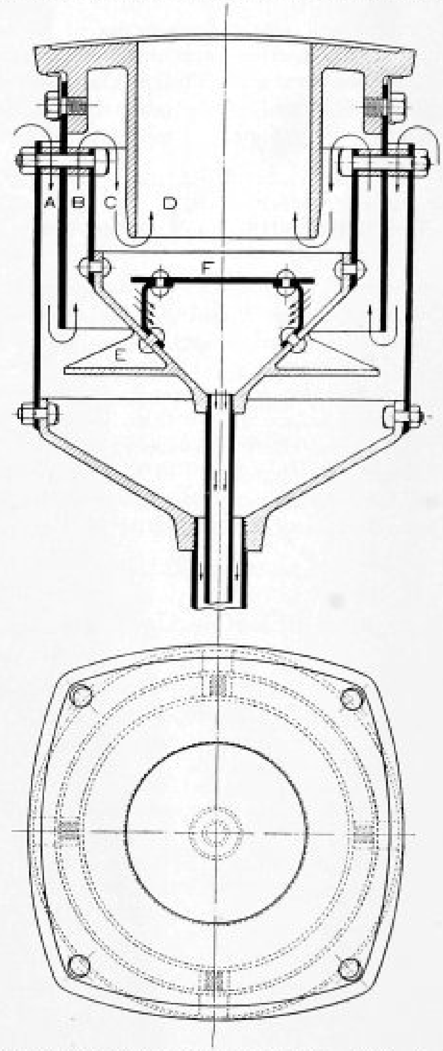
carbide through the relief valve on the top of the tank. A three-way cock delivers the water to the water-jacket of the carbide holder in use, thence overflowing into the catch basin or sewer. It is claimed that there is absolutely no waste of gas through this safety arrangement. Before the gas can escape it must exhaust all the water from the supply tank. In doing this it has removed the water so far from the carbide that no gas can be generated. The emergency pipe from the relief to the open air provides for any accident. Under ordinary conditions it is claimed that it is impossible for this generator to waste gas if left indefinitely with the water running.

The apparatus is made with either 1, 2 or 4 carbide holders. The other holders may be filled with carbide. Then they are ready for service when the first is exhausted. The exhaust holder may be quickly and easily cleaned by opening the waste gate in the sludge chamber. It can then be refilled with carbide, and is ready for use when needed. In this way generation of gas can be made continuous, regardless of the size of the job or length of time required.

The gas pressure may be varied from 2 to 15 pounds, as desired, by adjusting the screw on the relief valve. The cylinder, shown on the left of the illustration, is the purifier, and flash back with the filter on the top. Generators of this type can be built to meet any requirements and for any number of blow-pipes. With a suitable oxygen generator it is claimed that gas can be furnished at better than 3 cents per cubic feet.

The H. & B. Steam Drier.

Ed. C. Garratt & Company have placed on the market a steam drier which is in reality a steam separator applied to the inside of the boiler directly under the main stop valve. It is known as the H. & B., or Hageman & Broderson, patented steam drier. This device allows water that is drawn up mechanically by the current of steam passing from the boiler into the steam pipe to return by gravity before reaching the steam pipe. As shown by the sectional engraving, there are no working parts to get out of order. The drier is fastened directly to the shell of the boiler and held in position by four small studs. The steam is caused to pass through a series of pipes or bands, and in so doing it passes through different areas, which change the velocity without retarding the flow. The steam is first brought in a downward course through the passage *A*, traveling at the same velocity as in the steam pipe. It then flows upward through the passage *B*, which has a greater area than *A*; therefore the velocity is lessened as the

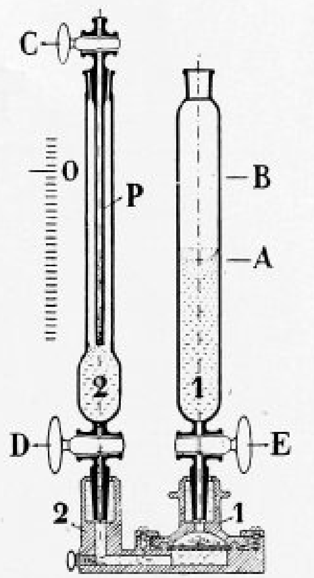


steam rises, throwing the water under the baffle plate *E*, and causing it to return to the water level. The steam passes through a similar process at *C* and *D*, where any moisture which may have passed *E* is expelled by means of the baffle plate *F*.

The Erfmann Boiler Water Controller.

The management and operating force of modern steam power plants have long recognized the necessity of eliminating the impurities contained in feed waters. This demand is present whether the steam generator is located on an ocean liner or tugboat, central power station or locomotive. In fact, industrial establishments of all kinds have long appreciated the need of some means whereby an accurate and simple analysis could be made of the boiler feed water and the prevention of further trouble effected. It is to supply this demand, which has now become insistent, that the Erfmann boiler water controller has been devised, and placed on sale by Brownrigg & Stevenson Company, New York. This is a new, practical and scientific departure in the practice of safe and economical boiler operation, and is the result of several years of observation and study. The value of the device is that it is always reliable, easily understood and operated, and gives the engineer of a power plant complete control of the boilers and the water he is using.

The apparatus consists of two graduated glass vessels, marked, respectively, No. 1 and No. 2; No. 2 is fitted with a pipette or inner tube. There is also an aluminum base acting as a filter, which holds the graduated vessels in position. The



case also contains three dropper bottles (two for chemicals and one for boiler water), a box of filter paper and a cleaning brush.

The method followed in using the controller is as follows: Tube No. 1 is filled up to the mark *A* with cold water taken from the feed-water supply. Then the yellow fluid from bottle No. 2 is added, filling the tube up to mark *B*. The contents of the tube are then well shaken and filtered into tube No. 2. Sufficient neutralizing reagent is then added to the solution in tube No. 2, to neutralize the effects of the impurities in the water, the proper amount being shown by the change of color of the solution. The total amount of liquid in tube No. 2 is then noted by marking on the graduated scale the height of the liquid in the tube. This is called the zero point, and it is by comparing this amount of liquid with the amount obtained after neutralizing an equal sample of the hot water from the boiler that determines the amount of chemical to be added to the boiler feed water. The divisions on the graduated glass indicate in ounces the quantity of neutralizer necessary to be added daily for each pound of boiler capacity; that is, each pound of water that is always kept in the boiler. If the amount is negative it indicates the amount of neutralizer necessary to be added daily. If the amount is positive it indicates the excess amount of neutralizer already in the boiler, and the daily amount should then be decreased until the test stands at zero point, which will indicate that the proper daily amount of neutralizer is being added.

The first time the boiler water is tested or examined it naturally contains a great deal in the shape of harmful elements, especially if the boiler has been in use for a long period. On the following day, however, it is probable that the amount of neutralizer needed will be considerably less. If, however, the controller indicates zero, the previous amount should be added each day. It is then sufficient to test the boiler water once a week, or, possibly, oftener, if any perceptible change in the feed water supply is noted. It will thus be seen that the Erfmann boiler water controller allows an exact and accurate determination of the amount of chemical which the boiler needs irrespective of any variation or change of conditions. It is claimed that if it is carefully used it guarantees clean boilers and permits no opportunity for the formation of incrustation or corrosion, thus assuring a long life for the boiler and greater economy of operation. The neutralizing medium used in connection with the controller will remove all material liable to form corrosion or incrustation, thus preventing pitting or the formation of scale, while it gradually removes any injurious material present. It changes these impurities into a soft, muddy precipitate, which sinks to the bottom of the boiler when it cools. It is odorless and non-volatile; it does not pass over with the steam; does not vary in composition, and therefore is adapted for use in any industry or in any climate.

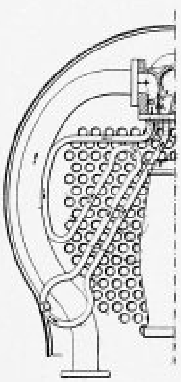
SELECTED BOILER PATENTS.

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

918,479. STEAM SEPARATOR AND HEATER. GEORGE ROBERT SISTERSON, OF LONDON, ENGLAND, ASSIGNOR TO SUPERHEATERS, LIMITED, OF LONDON, ENGLAND.

Claim 1.—In combination a steam main, a separator interposed therein comprising an inlet and an outlet compartment and means for baffling the steam passing from one compartment to the other, means connected



with the inlet compartment for receiving the water and wet steam deposited therein, means for heating said receiving means and a connection from the latter to the outlet compartment of the separator. Four claims.

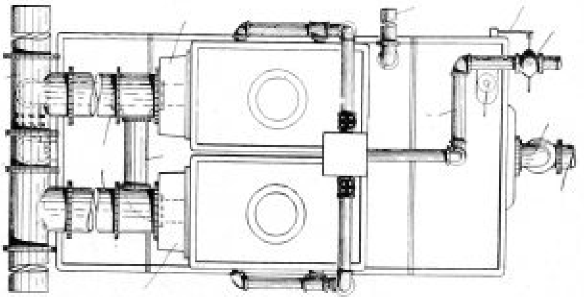
926,095. GRATE. EDWIN R. CAHOON, OF TROY, N. Y.

Claim 2.—A grate comprising a stationary grid formed with spaced bars, and a movable grid superposed on the stationary grid and formed with spaced bars having bare edges beveled inwardly from the top to the

bottom, the upper ends of the beveled spaces between the bars of the movable grid being narrower than the width of the bars of the stationary grid and the lower ends of said beveled spaces being wider than the width of the bars of the stationary grid, and the upper faces of the bars of the movable grid being wider than the spaces between the bars of the movable grid whereby when the grate is closed air passages will be formed between the lower edges of the bars of the movable grid and the upper edges of the bars of the stationary grid, and the edges of the bars of the movable grid will overhang the bars of the stationary grid. Nine claims.

926,109. FEED-WATER HEATER AND PURIFIER. JOSEPH WILLARD GAMBLE, OF PHILADELPHIA, PA.

Claim 6.—The combination of a plurality of heating units; a tank and an intermediate exterior passage connecting said heating units and tank;



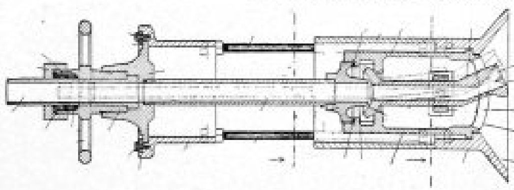
and means operating to take excessive strain or pressure off the extension tank. Ten claims.

926,115. FEED-WATER HEATER AND SEPARATOR. WILLIAM S. HALLOWELL AND JOSEPH WILLARD GAMBLE, OF PHILADELPHIA, PA.

Claim 1.—The combination of a feed-water heater; a heating system; a separator interposed between the source of steam supply and the heating system and heater, and having separate passages communicating with the heater and with the heating system, and a valve for controlling the flow of steam to either passage. Seventeen claims.

926,722. BOILER-FLUE CLEANER. WILLIAM JOSEPH BRADLEY, OF TROY, N. Y.

Claim 1.—An apparatus of the class described, comprising an inlet pipe; a rear plug connecting with same; a sleeve connecting with said rear plug provided with a slot in its inner end and having a valve seat; a hollow valve stem with a cupped rear end forming a steam-tight connection with the valve seat in the sleeve when in operation and pro-



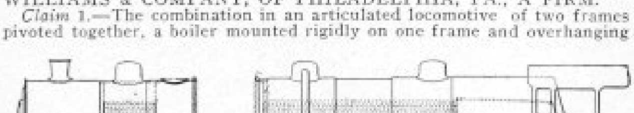
vided at its inner end with outlet apertures arranged at an angle to the axis of the valve stem; means adapted to swing the inner end of the valve stem radially in the slotted end of the sleeve comprising a controller lever, a fork and a block, a shaft rigidly attached to same and connected with said fork and block; and means for rotating the valve stem. Four claims.

926,958. PETROL-HEATED STEAM GENERATOR. MARIE AUGUSTIN NORMAND, OF HAVRE, FRANCE, ASSIGNOR TO ATELIERS ET CHANTIERS AUGUSTIN NORMAND, OF HAVRE, FRANCE, A CORPORATION OF FRANCE.

Claim 1.—In a steam generator, the combination of a combustion chamber, a nipple directly applied to and extending from one wall of said chamber and communicating directly with the latter, said nipple being provided with perforations in its side wall by which air is conducted into the combustion chamber, a burner extending into the nipple and an air chamber inclosing said nipple, and which supplies the same with air by means of said perforations. Five claims.

927,299. BOILER FOR LOCOMOTIVES. SAMUEL M. VAUCLAIN, OF PHILADELPHIA, PA., ASSIGNOR TO BURNHAM, WILLIAMS & COMPANY, OF PHILADELPHIA, PA., A FIRM.

Claim 1.—The combination in an articulated locomotive of two frames pivoted together, a boiler mounted rigidly on one frame and overhanging



the other frame, said boiler being made in two sections, one section detachably connected to the other. Eight claims.

927,329. BOILER FLUE. JOHN M. CROZIER, OF MINNEAPOLIS, MINN.

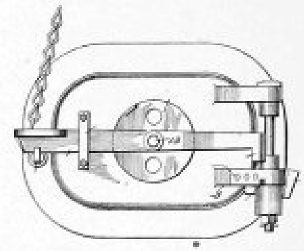
Claim 2.—A boiler flue having one end reduced in internal diameter and increased in external diameter, said increased external surface being conical and flaring toward the end of the flue. Three claims.

928,082. WATER GAGE. JULIUS TOROK, OF RENOVO, PA.

Claim 2.—In a water gage, the combination with a boiler, of a casing having the lower end thereof communicating with said boiler, a gooseneck connection carried by the upper end of said casing and establishing communication between said casing and said boiler, a float arranged within said casing, depending guides positioned within said casing for said float upper and lower sets of resilient contacts supported by said float, oppositely disposed electrodes arranged at the upper end of said casing and having oppositely-disposed semi-circular inner ends adapted to be engaged by said contacts for sounding an electric alarm, and means arranged within said casing for guiding said float. Three claims.

928,142. FIRE-DOOR LOCK. RICHARD M. M'COY, OF TERRE HAUTE, IND.

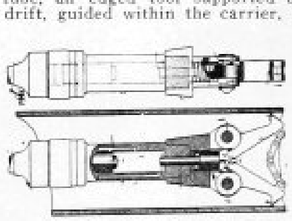
Claim 1.—In combination with a fire door and a frame therefor, said door and frame having hinge lugs pivotally connected together to permit the swinging of the door, a locking element on one of the door lugs movable angularly therewith when the door is swung, a latch mounted on the door and also having a releasing element and a key mounted against movement with the door and movable into and out of



engagement with the said locking element of one of the door lugs, means to cause said key to engage said locking element of said door lug when the door is in open position, and means on the said key and coincident with the releasing element of the door latch, when the door is open, to enable said door latch to be employed to cause said key to release the door. Three claims.

928,361. BOILER-TUBE CLEANER. SIDNEY MANTHORP COCKBURN, OF LONDON, ENGLAND.

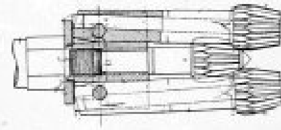
Claim 2.—Apparatus for effecting the separation of incrustation from the interior surface of a tube, comprising a carrier adapted to be inserted within the tube, an edged tool supported by the carrier in a pivoted manner, a drift, guided within the carrier, having a portion of



the tool seated therein constrained to move in the same direction as the drift, a spring for maintaining the drift in pressure contact with the tool and the edge of the tool with the incrustation during the entire operation of the apparatus, and means for striking a succession of blows on the drift. Six claims.

928,432. TUBE CLEANER. WILLIAM S. ELLIOTT, OF PITTSBURG, PA.

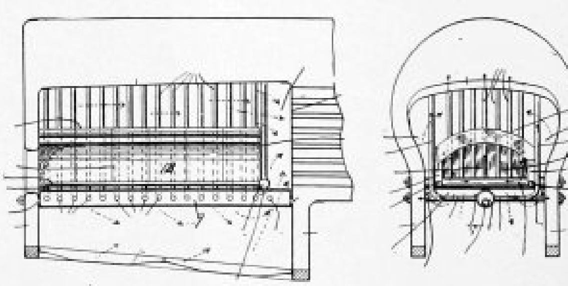
Claim 1.—A cutter for tube cleaners, comprising an integral body having thereon two series of longitudinally extending cutting edges,



the cutting edges of the two series being in staggered relation to each other, and the cutting edges of one series being connected to the adjacent cutting edges of the other series by oblique cross-cutting edges, said cutter being mounted for free rotation. Eleven claims.

928,880. LOCOMOTIVE BOILER. OREL D. ORVIS, OF JERSEY CITY, N. J.

Claim 1.—In a locomotive, the combination with a boiler, a furnace, a fire-box, a plurality of water tubes forming a water grate at the bottom of said fire-box, side walls formed by a portion of said watertubes, a lining within said side walls, a wall closing said fire-box, composed



partly of watertubes and partly of fire-proof material, an arch of fire-proof material above said grate and connections between said water grate and said boiler. Five claims.

928,650. LOW-WATER ALARM. FREDERICK D. GOODNOUGH, OF DETROIT, Mich.

Claim.—The combination of a casing, a float in said casing, a stem extending upward from said float and provided with a valve at its upper end, a passageway extending from said casing, said stem extending into said passageway, a part in said passageway provided with an opening therethrough, and a valve seat in said opening, said stem being adapted to fit in said opening so as to be guided by its walls, said valve being adapted to come against said valve seat, and a signal adapted to be sounded by the passage of steam through said opening, the part being provided with a passageway in its wall opening at the lower end of said part and opening into the bore thereof just below the valve seat. One claim.

THE BOILER MAKER

OCTOBER, 1909

AN INTERESTING METHOD OF RENEWING A FURNACE IN A SCOTCH BOILER.

BY NEIL B. MAIR.

When a boiler furnace, in which a crack or series of cracks has developed, or in which some other failure has occurred, requires to be renewed, it is usually the desire of the owners of the vessel to which the boiler belonged, as well as the representatives of the various insurance companies, to have the new furnace precisely similar to the disturbed one. No amount of patching, as a makeshift, or of assurances such as that, this or that make of furnace is just as good, etc., will be sufficient for the average careful surveyor, particularly when the boiler concerned has a working pressure of, say, 180 pounds per square inch. It is eminently desirable that any new or renewed part of a boiler does not prejudice the efficiency of the existing or remaining parts through an undue strain which may be set up by an unequal expansion and contraction of the plates, consequent to the placing of the new parts side by side with the old ones. Hence the desirability of having, as far as possible, a *duplicate* part fitted, even where a boiler furnace is concerned.

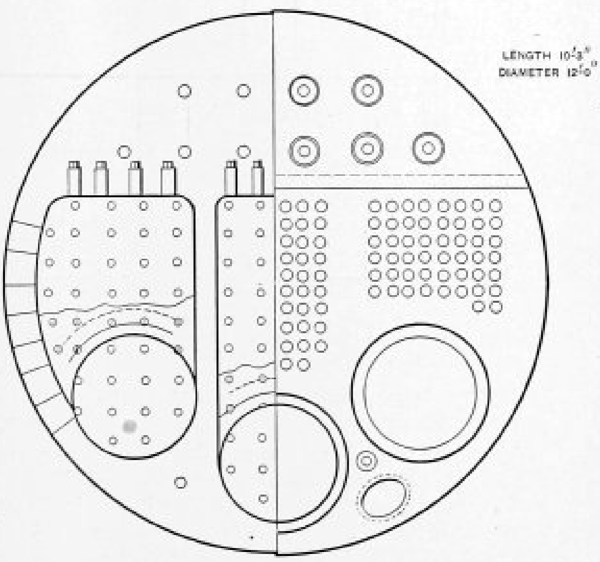


FIG. 1.—FRONT ELEVATION.

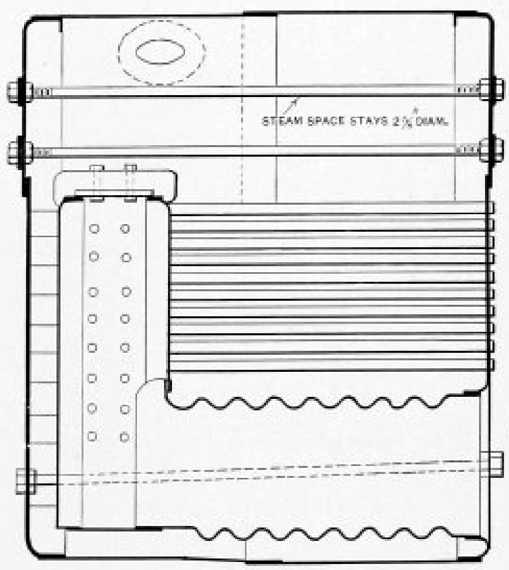


FIG. 2.—LONGITUDINAL SECTION.

A vessel having a boiler in which a serious crack had developed reached port lately, and following the usual insurance surveyor's examination and report the specifications for the cutting out and renewing of the furnace were duly issued to the various boiler-repairing firms. There were not a few diverse opinions as to the manner in which the work was to be performed, since, owing to the construction of the boiler, as shown in Figs. 1 and 2, there were three ways in which the repairs could be satisfactorily executed.

The method usually adopted in similar jobs is to drill out all rivets in the circumferential seam at the front-end plate of the boiler, and remove *all combustion chamber stays,* as well as steam space stays, and the stays in the lower end of the front plate at the sludge door. The end plate, with furnaces and combustion chambers, would then be ready to be removed in an entirety, and the work of renewing proceeded with.

Another plan sometimes practicable is to remove the end plate, employing the same means as in the first method, viz.: to remove all circumferential rivets in the end plate and all fore-and-aft stays, and to drill out the chamber stays in that *chamber only* whose furnace is to be renewed. In this way, after drilling out the rivets at the furnace mouths of the two furnaces whose chambers are to remain undisturbed, the end plate with the cracked furnace would then be ready to be withdrawn from the interior of the boiler.

To the almost prohibitive cost of either of these methods of repair must be added the price of a complete set of tubes in the first case, while in the second example two-thirds of the tubes would be sacrificed, for, with care, the tubes in the withdrawn chamber (by the second method) could be retained.

It is a third method (the one actually adopted) which we desire to describe in detail, believing that it is of value as an example of a more economical method of doing a piece of work at a time when *economy* with *dispatch* is demanded.

After the preliminary "upheaval" on shipboard, when the funnel, with up-take, mountings, steam pipes, etc, were removed, the boiler was taken out and placed in the repairing yard. Here the boiler was placed on a radial drilling machine, Fig. 3, where all rivets in the circumferential seam of the end plate were drilled out with a twist drill, ⅛ inch smaller than the diameter of the rivet, to ensure that the existing rivet holes would not be damaged in the drilling of the rivet.

The boiler was then lifted off from the drilling machine, and boiler makers started to clear out the remainder of the rivets left in the holes after drilling. At the same time the nuts (on the inside and outside of the front-end plate) on the front end of the steam space stays were cut off, and with pneumatic tools the boiler makers cut an opening on the end plate, round the "neck" of each stay (on the front plate only), about ¼ inch broad; or, in other words, they cut the stay holes ½ inch

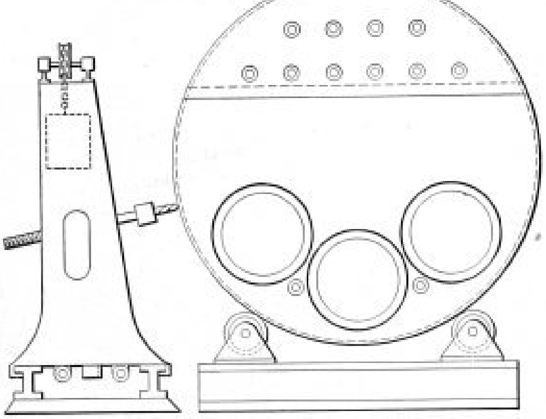


FIG. 3.—BOILER ON RADIAL DRILLING MACHINE.

larger in diameter, care, of course, being taken not to damage the threads of the stays. The stays were thus clear of the end plate.

A driller was also put to work with an air drill to bore out all rivets in the inner tube sheets and the lower side of the furnace where it joins the combustion chamber side sheets. These rivets were then driven out. (See Fig. 4.)

The girder stays on the combustion chamber crowns were then slackened back, but not removed from the interior of the boiler, and the stays from end to end of the boiler, just over the sludge door, were removed entirely.

The boiler was then placed in suitable position (see Fig. 5) with its back to the floor of the shop, and the overhead crane soon had the end plate, furnaces and inner tube sheets, with every tube intact, suspended in mid-air, the whole being secured by means of long eye-bolts, placed through the tubes

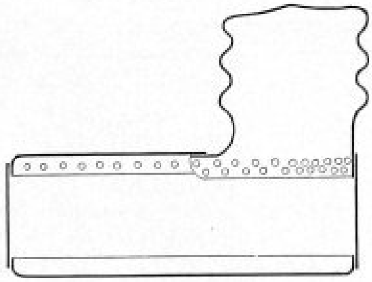


FIG. 4.—SECTION OF COMBUSTION CHAMBER, SHOWING ONLY LINE OF RIVETS DISTURBED.

and flues, with plate washers and nuts on the combustion chamber side.

The back ends of the combustion chamber, with the side sheets and every stay complete, were thus left in their original position in the interior of the boiler, as well as the ten steam-space stays or long fore-and-aft stays. (See Fig. 5.)

The part of the boiler taken out was then turned over, and the rivets in the cracked furnace were bored out at the front and back ends, and the furnace withdrawn. By using the old furnace as a pattern all rivet holes were carefully "lifted" by means of sheet iron templates, and all holes drilled in the new furnace.

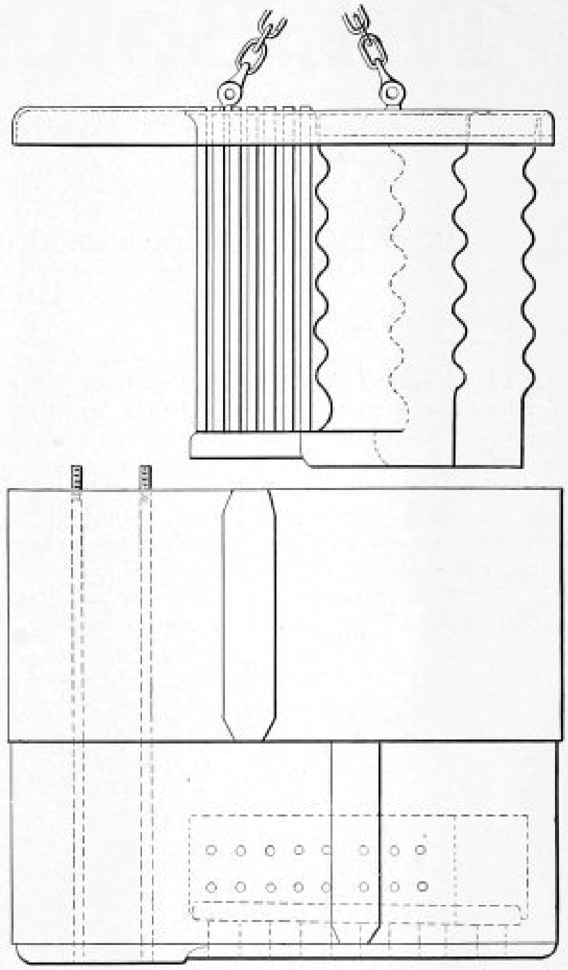


FIG. 5.—SHOWING REMOVAL OF END PLATE, FURNACES AND INNER TUBE SHEET WITH EVERY TUBE INTACT. BOILER SHELL, STEAM-SPACE STAYS AND PART OF COMBUSTION CHAMBER LEFT UNDISTURBED.

Attention had meantime been paid to the front-end plate, or to that part of it containing the holes for stay ends, which had been cut to facilitate the withdrawal from the boiler. To compensate for the amount cut out a piece of plate was fitted on each hole (see Fig. 6) measuring 12 inches in diameter and ¾ inch thick, with a stay hole in the center, a good fit for the stay, and having ⅞-inch rivet holes pitched regularly, with the usual landing round the edge of the washer plate to rivet same

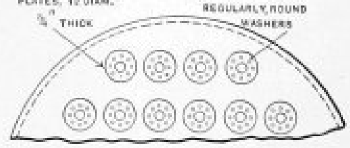


FIG. 6.—PLATE WASHERS ON STAYS.

to the end plate. These plates, while strengthening the part of the plate round the stay, also served to give a new calking edge round the stays. They were riveted by the hydraulic machine.

The new furnace was drawn into position by means of long bolts and hooks, as shown in Fig. 7, and all holes faired and well bolted up together. The rivets through the furnace mouth were then driven, and also the rivets through the inner tube sheet at the saddle plate, and the landing edges were carefully calked on either side.

The furnaces were now ready to be lifted back and drawn into the boiler. To accomplish this several large bolts were placed through the tubes and furnaces at the front plate and back of the combustion chamber. A great "purchase" was thus obtained, and little difficulty was encountered in getting the front plate (or head) and furnaces in their place in the interior of the boiler again. All rivet holes were then faired, and the whole job securely bolted up. The circumferential seam was next riveted and calked on both sides.

The boiler was turned after the riveting and calking of the end plate, so as to bring the sides of the combustion chamber into a horizontal position to facilitate the driving of the rivets by hand, first on one side of the flange of the tube sheets and

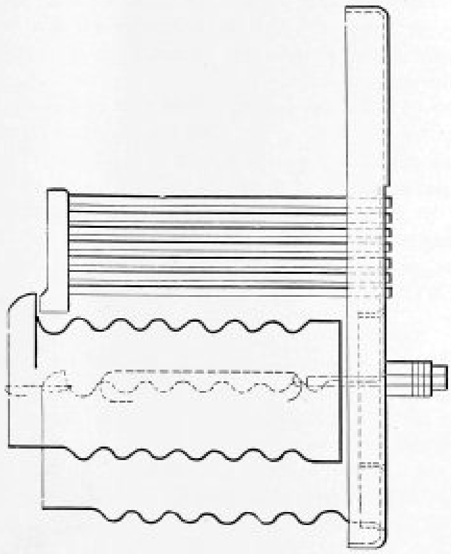


FIG. 7.—NEW FURNACE BEING DRAWN INTO END PLATE.

furnaces, and after turning the boiler round, so that the unriveted side was horizontal to the floor, the remaining rivets were driven. The seams, or landing edges, were now all thoroughly calked inside the boiler and inside the chamber by the pneumatic hammer. The new bottom stays were next placed in position and secured, while all the top stays (in the steam space) were calked and jointed.

After the usual "finishing up," when the "tail ends" of the little jobs had been completed, the boiler was filled with water for testing, and pressed to one and one-half times the working pressure. The repair having proved satisfactory the boiler was duly placed on board ship, where the replacing of the various disturbed mountings and fittings was performed. The whole time occupied on this job was barely four weeks.

It is interesting to note that the contractors allowed in their tender for new tubes and stays in the combustion chamber, and steam space, which we have seen it was unnecessary to remove.

PERSONAL.

A. K. Larmon has been appointed master boiler maker of the National Railways of Mexico, at Chihuahua, Mexico.

T. Smitz has been made foreman of the Richmond works of the American Locomotive Company. Mr. Smitz succeeds Mr. J. T. Goodwin, who has become associated with the National Tube Company, of Pittsburg, Pa.

E. P. Cavanaugh, general boiler inspector of the Baltimore & Ohio Railroad, was killed recently in a train wreck.

C. E. Carpenter and W. L. Curlin have severed their connection with the Schurchardt & Schutte Company, and their plans for the future will be announced later.

NOTES ON THE STRENGTH OF RIVETED JOINTS.

BY H. S. JEFFERY.

In this article the writer will endeavor to show that figuring out the strength of a riveted joint requires more considerations than are usually taken into account.

First, let us assume that we are going to build a first-class boiler in every respect, and this, of course, means that we are going to drill the holes in place. This being done, a set factor of safety can be adopted, and this we will assume to be 4; therefore if the efficiency of the longitudinal seam is, say, 85 percent, the boiler shell ½-inch steel, 60,000 pounds tensile strength, and the diameter of the boiler 60 inches, the working pressure will be:

$$\frac{60{,}000 \times .85 \times 1}{60 \times 4} = 212.5 \text{ pounds.}$$

The efficiency, 85 percent, as mentioned, is taken as the efficiency of the net section of plate at the outer row of rivets of a triple-riveted, double-strapped butt joint, and it will be assumed that the combined efficiency of the two inner net sections of plate and one rivet in single shear is 86 percent.

The point to consider at present is that the same factor of safety has been used in both cases—for the plate and for the rivets.

Now, if the holes in the plate were punched, the punching would injure the plate only; in consequence the factor of safety would be increased, say, to 4.5, and this, of course, would mean a reduction in the pressure. The injury to the plate increases the factor of safety, but this increase should be for the plate only, not for the rivets, for the punching of the holes has not reduced the shearing strength of the rivets.

As before stated the net section of plate is in this case the weakest point, and of course the efficiency is figured from that source; but another condition now presents itself, in that the 86 percent efficiency represented the combined efficiency of the inner net sections of plate, and the rivet, in single shear, in the other row. Inasmuch as the punching damaged the plate only, the factor of safety for the inner net section of plate would be 4.5, and the rivets in the other row, not being injured by the punching, should retain their original factor of safety of 4.

Now, if the matter is carried, so to speak, "to split the hair," it will be seen that it is not proper in some cases to add the two efficiencies together, for the reason that each has its own factor of safety, although it appears that as far as the factor of safety of the rivet is concerned it is rather a variable amount, and regulated by whatever is allowed for the plate.

With a factor of safety of 4.5, the allowable working pressure will be:

$$\frac{60{,}000 \times .85 \times 1}{60 \times 4.5} = 188 \text{ pounds.}$$

Using the same factor of safety, and considering the efficiency of the net section of plate, inner row only, which will be estimated at 75 percent, the working pressure will be:

$$\frac{60{,}000 \times .75 \times 1}{60 \times 4.5} = 166 \text{ pounds.}$$

Naturally, this does not represent the allowable working pressure, for the value of the rivet in the outer row has not been considered, and since the combined efficiency was stated to be 86 percent, and the net section of plate, inner row, is 75 percent, it follows that the efficiency of the rivet is 11 percent, therefore the working pressure will be:

$$\frac{60{,}000 \times .11 \times 1}{60 \times 4} = 27.5 \text{ pounds.}$$

This 27.5 pounds, added to the 166 pounds, makes 193.5 pounds working pressure.

It should be remembered that the 193.5 pounds is based on an efficiency of 86 percent, using two different factors of safety, and if only one factor of safety, 4.5, is used the working pressure will be:

$$\frac{60,000 \times .86 \times 1}{60 \times 4.5} = 191 \text{ pounds},$$

which is 2.5 pounds less than that obtained by using two factors of safety.

With lap-riveted joints the factor of safety plays no small part, for, although the net section of plate in some cases has a greater efficiency than the rivets, the latter may, however, give a greater working pressure.

Considering that the longitudinal seam was drilled, and the factor of safety is 4, the working pressure will be figured from the lowest efficiency of the riveted joint, which in this case will be assumed to be 70 percent for the rivets and 75 percent for the plate. The working pressure will be:

$$\frac{60,000 \times .70 \times 1}{60 \times 4} = 175 \text{ pounds}.$$

Now, if the holes were punched, the factor of safety would be increased, say, to 4.5, and the working pressure would be less, particularly so were the efficiency of the joint to be taken at 70 percent.

Inasmuch as punching the plate injures only the plate, the working pressure allowable should be figured out from that source, and if less than the working pressure previously found it should be the allowable working pressure.

The working pressure, with a rivet efficiency of 70 percent and a factor of safety of 4, was found to be 175 pounds, but by figuring the working pressure with a plate efficiency of 75 percent and a factor of safety of 4.5, it works out as follows:

$$\frac{60,000 \times .75 \times 1}{60 \times 4.5} = 166 \text{ pounds},$$

which, as will be noted, is less than the pressure with the 70 percent efficiency.

The above considerations are intended to show the real need of considering the factor of safety. In many publications tables of riveted joints are given, and many of these tables are worthless; in fact, are injurious, for the efficiency of the joint as given in many cases is simply the efficiency of the plate, when the lowest efficiency may actually be in the rivets.

The Engineering Standards Committee, of Great Britain, have just issued a standard specification for charcoal-iron lap-welded boiler tubes. The report has been drawn up at the request of tube manufacturers, and issued in advance of the specification for wrought iron for other purposes. The chief mechanical tests in connection with the specification are that the tubes should be annealed at both ends, and that strips cut from them should show a tensile strength between the limits of 19 and 24 tons per square inch inclusive, with a contraction of area of not less than 45 percent. Samples of tubes should also stand bulging to a diameter 15 percent greater when hot and 10 percent greater when cold, than the normal diameter, while a piece of tube 2 inches long placed on end should stand hammering down until it is 1⅜ inches long without showing crack or flaw. A piece of tube should also stand hammering flat without showing crack or flaw, and all tubes should be capable of resisting an internal hydraulic pressure of at least 750 pounds per square inch. The committee have at present under consideration a standard specification for steel tubes for locomotive boilers.—*Vulcan.*

DEVELOPMENT OF AN IRREGULAR PIPE CONNECTION.

BY C. B. LINSTROM.

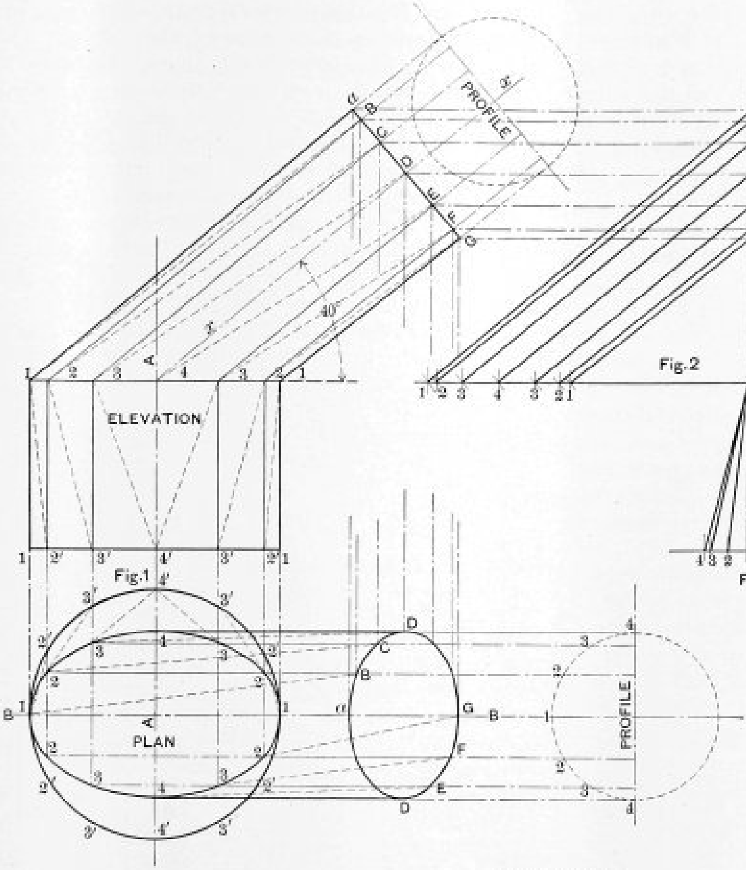
There are many cases that arise in the course of a boiler maker's experience where he is required to make irregular pipe connections. One such instance is shown in Fig. 1, which represents a pipe connecting to an irregular tapering form, which is commonly called a transition piece. In this case the pipe makes a connection at an angle of 40 degrees to the horizontal; however, the principles of development, as applied to this problem, are applicable to a connection at any angle. The principles entering into the development of this layout are very simple if the elementary elements of triangulation are thoroughly understood.

In order to make the desired connection it will be necessary to construct a transition piece, which must taper from a round base to an elliptical top; the major axis of the ellipse being equal to the diameter of the base, and the minor axis equal in diameter to the pipe connection. The development for the ellipse can be very readily determined by projection drawing; the explanation of this operation is shown in the construction of Fig. 1.

CONSTRUCTION OF PLAN AND ELEVATION.

First draw the center lines *A-A* and *B-B* of a convenient length and at right angles to each other. Upon the line *A-A* draw the base or lower portion of the elevation to the required dimensions, then make the desired pipe connection by drawing the line *x-x* to the required angle; in this layout the angle is 40 degrees to the horizontal. The line *x-x* represents the axis of the connecting pipe. At right angles to the axis and through point *D*, draw the line *a-G*, and make it equal in length to the diameter of the pipe; connect the points *a* and *G* to the horizontal line 1-1. On the line *x-x* locate the profile which represents the opening of the pipe; draw it to a radius equal to one-half the diameter of the required pipe. Divide one-half of its circumference into any number of equal spaces, in this case six. Project these points parallel to the line *X-x* until they intersect the line 1-1, or the top of the transition piece.

The next procedure will be the development of the plan view. Upon the lines *B-B* and *A-A*, and using the intersection between these lines as an apex, draw a circle equal in diameter to the base of the transition piece. Divide its outline into the same number of equal spaces as are shown divided in the profile in elevation. Through these points of division and parallel to the line *A-A*, or at right angles to the line *B-B*, draw projectors to the elevation. It is then required to develop the plan view for the pipe connection. Upon the line *B-B* locate the profile for the opening in the pipe at a convenient distance from the plan; divide one-half of its periphery into the same number of equal spaces as are shown in the profile side elevation. Project these points of division parallel to line *B-B* until they intersect the corresponding projectors drawn through the points of division on the large circle. A line traced through the intersection of these respective lines represents the top of the transition piece, and which is shown elliptical. It will be seen that the opening in the pipe is also shown elliptical in the plan view. This is due to the fact that in viewing this part from above it will be seen foreshortened, or as shown in the drawing. The development for this portion is determined in identically the same way as explained for the large ellipse. Projectors are dropped from the elevation to the plan until they intersect the corresponding lines which run parallel to the line *B-B*. A line traced through the intersection of these lines represents a foreshortened view of the opening in the connecting pipe. Number the points of intersection on the large ellipse from 1 to 4, inclusive, and on the small ellipse letter the points *a, B, C, D, E, F* and *G*. Connect these points with dotted and solid construction lines as shown. From 4 to *D*, 3 to *E*, 2 to *F* and 1 to *G* connect with solid lines; from 4 to *E*, 3 to *F* and 2 to *G* connect with dotted lines. Draw in the remaining construction lines in a like manner.



CONSTRUCTION.

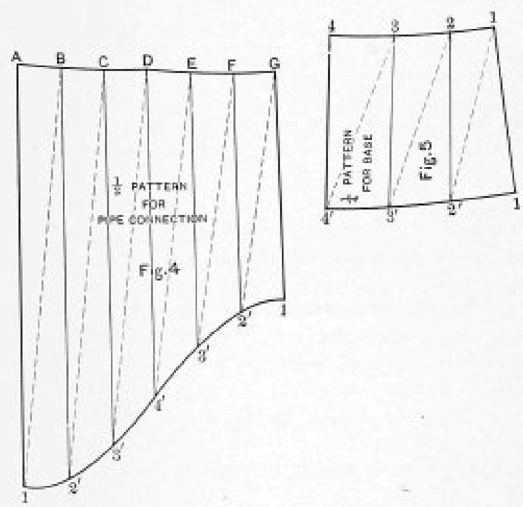
We now have sufficient data in order to determine the true length of lines for the development of the pattern. Referring to Figs. 2 and 3 it will be seen how these lines are obtained. The base of the triangles are taken from the plan and the heights from the elevation. The hypothenuse is the required or true length of line.

Fig. 2 represents the true length of lines for the pipe connection, and Fig. 3 represents those for the transition piece or the base connection. An illustration for the development of one of these triangles will be given; then it will not be necessary to go into detail and describe the various operations for each respective diagram. Set the trammel points or dividers equal in length to the distance 4-*D*, plan view, and upon the base of the diagram of triangles locate this distance. The height for this base line is *D*, which is shown projected from the elevation to the vertical line of the triangles. A line connecting these points is the true length of line. The remaining triangles are determined in the same manner.

TO LAY OUT THE PATTERNS.

The pattern for the pipe will be developed first. It will be seen by referring to Fig. 4 that only one-half the pattern is shown developed. As the other half is laid out in the same manner, a complete layout was not deemed necessary.

First draw the vertical line *A*-1 equal in length to the distance *a* to 1 of the elevation, then with the dividers set equal in length from 1 to 2 of the large ellipse plan view, and using *A* in the pattern as an apex, draw an arc. Then set the trammel points equal in length to the dotted line 1-*B* of the diagram of triangles, and using 1 in the pattern as an apex, draw an arc through the arc previously drawn which locates point *B*. With 1 as an apex and the dividers set equal to the distance 1-2 of the profile, draw an arc, then set the trammel



PATTERNS.

points equal to the solid line 2-*B* of the triangles, and using *B* in the pattern as an apex, draw an arc through the arc just drawn. Continue in a like manner, using alternately the true length of dotted and solid lines until the pattern is complete.

In the development of the pattern for the base connection one-quarter of the pattern is shown developed; as all four quarters are equal it would not be necessary to involve the extra time in a complete construction, when sufficient data can be obtained from one quarter. The solid line 4-4 is first drawn, and which is equal to the height of the object. The spaces for the top, or for the elliptical connection, are obtained from large ellipse, plan view, and the spaces for the base are taken from the large circle. The true length of lines for its development are shown in Fig. 3. As the operation of constructing this portion of the layout is comparatively easy, it will need no further explanation. It should always be borne in mind that accuracy is the main requisite in problems of this character, and if care is not exercised, especially where so many lines are involved, the pattern will be wrong, which will involve an unnecessary cost in both material and labor.

The Relation of the Character of Coals to the Prevention of Smoke.*

BY D. T. RANDALL†

The semi-bituminous and bituminous coals are the most extensively used of all the fuels which are available for generating steam. Containing as they do a considerable quantity of volatile matter, which is given off when the coals are heated in the furnace, it is difficult to burn them under boilers so as to secure perfect combustion and freedom from smoke. Specially designed furnaces and careful operation are required to get good results.

The difference in the character of coals is only partly shown by the proximate analyses which are commonly used, but to one familiar with coals these analyses indicate in a general way the leading characteristics of the coals.

To show the difference in fuels the following table has been prepared:

TABLE I.—ANALYSES OF FUELS AS DELIVERED AND USED.

	Coke.	Anthracite Pea Coal.	Pocahontas Coal.	Pittsburg Coal.	Indiana Coal.
Moisture	4.67	4.75	1.12	2.48	9.62
Volatile matter	2.82	2.90	17.24	38.74	36.14
Fixed carbon	82.61	77.15	74.84	49.18	41.22
Ash	9.90	15.20	6.80	9.60	13.02
	100.00	100.00	100.00	100.00	100.00
Sulphur	......	0.80	0.71	1.85	4.43
B. T. U.	12,206	11,886	14,530	13,172	11,122

It will be noted that coals vary both in their composition and in their heating values (B. T. U.), and in consequence they are more or less valuable as fuel, depending on these variations.

Other things being equal, a fuel high in fixed carbon is more easily burned in a common furnace without loss of heat and without smoke than those of lower percentages. Coke and anthracite coals are examples of this class of fuels.

The percentage of moisture is not of great importance except in cases in which the coal is naturally high in moisture, or in which the coal is very wet, as a result of washing or exposure to storms. Moisture in small percentages seems to aid combustion, but in larger amounts it retards the ignition of the gases and lowers the furnace temperature. It may or may not increase the smoke, depending on the character of the fuel.

The percentage of ash, and especially the character of the ash, is of importance in connection with the smoke problem. Ash which is fusible and runs down onto the grate bars may cause smoke by shutting off the flow of air through the fuel, and by increasing the poking which is necessary to keep the grates free. Coals which clinker badly require more attention from the firemen, and poking the fire is a common cause of smoke.

There is a great difference in the behavior of the same coals when burned under different furnace conditions and in different furnaces. Some grates and stokers are adapted to handle coals which are burned with great difficulty on other equipment. The rate of burning per square foot of grate is often the deciding factor as to whether a given coal may be used or not. This is principally due to the higher temperatures which are obtained with high rates of combustion, and its effect on the fusible portion of the ash of the coal. Investigations are now being made to determine the characteristics of the ash of representative coals, as related to the clinker formed at various temperatures.

So far as smoke is concerned the volatile matter is of the greatest importance. The quantity of volatile matter is not a true measure of the difficulty of burning a coal, but to one familiar with the various coal fields it is of great assistance in choosing a suitable coal or in designing a furnace suited to the given coal. Investigations relating to the nature of volatile matter in representative coals have been carried on at the Government fuel testing plant at the University of Ohio and at the University of Illinois. The results show that the difference in the gases given off from coals may be due to the composition of the coal and to the temperatures to which the coal is subjected when placed in the furnace. The higher temperatures tend to distil the volatile matter more rapidly and drive off the heavy hydrocarbon in forms which are difficult to burn without smoke.

TABLE II.—ABSOLUTE QUANTITIES OF SMOKING PRODUCTS IN TEN MINUTES, HEATING AT DIFFERENT TEMPERATURE.*

Coal	Temperature Degrees C		Smoking Products.	
	Furnace.	Coal.	Tar Percent.	C_6H_6 — c.c.
3 Connellsville	600	441	4.9	61
1 Ziegler, Ill	600	440	6.8	51
3 Connellsville	700	562	11.0	145
1 Ziegler	700	545	7.8	24
16 Pocahontas	700	599	4.2	138

* See paper by Porter & Ovitz in Journal of American Chemical Society, Vol. XXX.

The above table gives some idea of the complicated relation between the temperature of the coals in the furnace and the compositions of the various gases to be burned. Investigations of this character are necessary to determine the characteristics of coals from each of the representative beds.

The combustion of coke or other fuels high in fixed carbon is comparatively simple. The greater portion of the fuel is burned on the grate; the remainder, in the form of gas, burns at a short distance above the bed of fuel. This may readily be observed on a fire of anthracite coal in which there is only a small percentage of volatile matter.

In burning bituminous coals, however, the difficulties are much greater and for the reasons given above. The volatile matter from some coals is set free more readily than from others, and with some coals the nature of the volatile matter given off is such as to make it very difficult to secure complete combustion. Smoke is an indication of incomplete combustion, and the problem of reducing the amount of smoke is important, not only from the standpoint of the smoke

TABLE III.—SHOWING RELATION OF SMOKE TO CO IN FLUE GASES.*

Average percent of black smoke	0.	7.1	15.5	24.7	34.7	43.1	52.9
Average percent CO in flue gases	0.05	0.11	0.11	0.14	0.21	0.33	0.35
No. of tests averaged	37.	18.	56.	51.	36.	17.	4.

* See U. S. Geological Survey Bulletin 325, pages 101 and 167.

*A paper presented at the Syracuse meeting of the International Association for the Prevention of Smoke, June 24-26, 1909.

†Engineer in charge of fuel engineering department, Arthur D. Little, Inc., Laboratory, of Engineering Chemistry, Boston, Mass.

inspector, but also because of the losses in combustible gases, such as carbon monoxide (*CO*) and hydrogen, which escapes with the smoke.

Experiments by several investigators have shown that whenever smoke is given off there is also a considerable quantity of carbon monoxide gas, and that as a rule this gas is accompanied by small percentages of hydrogen and hydrocarbon compounds. The losses due to these combustible gases which are found in connection with a smoky stack may vary between 1 and 10 percent of the fuel.

TABLE IV.—SHOWING RELATION BETWEEN CO IN FLUE GASES AND OTHER COMBUSTIBLE GASES.*

Boiler Furnace.	Smoky.				Clear.			
	CO_2.	CO.	CH_4.	H_2.	CO_2.	CO.	CH_4.	H_2.
Hand fired....	10.95	3.00	0.70	3.23	8.15	0.0	0.0	0.0

* See Manchester (England) Smoke Abatement Report.

When burning a bituminous coal, the volatile matter must be raised to a high temperature while mixed with a sufficient quantity of air and burned on its passage from the fuel bed to the surfaces of the boiler. In most boiler settings this distance for combustion is very short, and when the gases strike the cold surfaces of the boiler shell or tubes they cool below the temperature at which they will burn rapidly, and as a result some escape unburned and others are only partially burned, as shown by the heavy deposits of soot. In properly designed furnaces the space provided for combustion is large for coals giving off high percentages of volatile combustible. Even in such furnaces the firing must be carefully done, or at times enough air cannot be supplied to the gas, and smoke results for short periods. In most plants the time required for the gases to pass from the fuel bed to the top of the stack is between ten and fifteen seconds, assuming the velocity to be reasonably uniform at different sections, then it will be seen that the gases pass from the fuel bed to a distance of, say, 12 feet in one second. At the end of this period there is but little opportunity for the gases to burn. This will make clear the great importance of a sufficient air supply, properly distributed, and an ample space above or back of the grates in which the gases may thoroughly mix and burn within considerably less than one second of time.

That there is a loss due to the volatile gases escaping unburned from an ordinary furnace is shown very clearly by the results of tests made on house heating boilers. The following table gives figures obtained on two series of tests for the purpose of determining the fuel values of several coals and briquets* when burned in a house-heating boiler:

TABLE V.—THE RELATION OF VOLATILE MATTER OF SMOKE AND UNCONSUMED GASES. *

Number of Tests Averaged.	Volatile Matter in the Combustible.	Ash in Dry Coal.	Efficiency.	Black Smoke.	CO in Dry Flue Gases
4	18.30	8.00	60.56	18.2	0.44
12	22.71	8.94	56.33	18.0	0.50
7	34.70	11.27	54.11	22.1	0.55
11	38.79	15.02	47.19	30.8	0.62
16	44.46	14.57	47.19	32.9	0.74

* See U. S. Geological Survey Bulletin No. 366.

The furnace in which the results shown in Table V. were obtained is best suited to coke, anthracite, or low volatile coals, and, as will be seen, is not adapted for burning bituminous coals with good efficiency, yet many furnaces having practically the same features, such as a grate surrounded by heating surface, and a small combustion chamber, are used in power plants for burning high volatile coals.

Even with furnaces of improved design it is difficult to charge the coal by hand firing and secure smokeless combustion. This is due to the fact that a comparatively large quantity of gas is liberated immediately after firing at the same time the fuel bed has been thickened, and the air enters with more difficulty and without being well distributed with respect to the gases rising from the bed. With such a furnace the loss of combustible gases may be reduced to 5 percent or less, depending on the coal and the operation. It is because of the advantage in having the coal gradually heated and the gases distilled from it at a low temperature that a mechanical means of feeding the coal to the furnace is usually more successful in the prevention of smoke.

A good furnace should permit the burning of bituminous coal in sufficient quantities without loss of escaping gases or the formation of smoke when the air supply is about 50 percent in excess of the theoretical amount. It has been found by experience that to approach this performance the coal must be fed regularly in small quantities, gradually heated if possible, and the air supply admitted in such a way as to thoroughly mix with the distilled gases. Furthermore, the space for burning the gases should be large and preferably enclosed in firebrick.

A furnace suitable for certain coals may be entirely unsuited to other coals, and it is only after a careful study of all the factors, such as power to be generated, size and kind of boiler to be used, and the coals available, that an engineer can undertake to design a furnace which will be satisfactory and at the same time give good economy under operating conditions.

Even after the best types of furnaces are installed it is necessary to supervise the operation of the boiler plant closely in order to secure the best results. The proper drafts, the best thickness of fire for any given coal when burned on grates at the rate required for the plant, and the best method for the removal of ash and clinkers to prevent loss of fuel into the ash pit are all factors in securing the highest economy. Failure to attend to these important details may easily cause a loss of as much as 10 percent in the fuel fed to the furnaces. In conclusion:

1. Even well-designed furnaces may be expected to give off smoke if *improperly operated* or under any of the following conditions:
   - (*a*) When a new fire is built in a cold furnace.
   - (*b*) When an excessive amount of coal is burned on the grate, making it difficult or impossible to properly mix the air with the gases and burn them in the furnace.
   - (*c*) When the rate of combustion is suddenly changed, due to a change in demand for steam, for the same reasons as under (*b*).
2. Smoke may be reduced and in most cases prevented
   - (*d*) By burning a fuel having a small amount of volatile matter.
   - (*e*) By burning a bituminous coal in a specially designed furnace, with more than ordinary care on the part of the fireman, under the supervision of a competent engineer.

According to *Poor's Manual* for 1909 the total mileage of the steam railroads in the United States Dec. 31, 1908, was 232,046 miles, an increase in the year of 3,918 miles. The total number of passengers carried in 1908 was 891,275,003, or 3,626,429 more than were carried during the previous year. The total amount of freight moved during the year was 1,521,065,494 tons, or 201,144,787 tons less than were moved in 1907. The total capital liabilities of the railroads, including stock, bonds, equipment, obligations, etc., were $17,234,886,215, an increase of $743,473,146 in the year.

THE BOILER SHOP OF THE GREATEST STEEL PLANT IN THE WORLD.*

Since the organization of the Indiana Steel Company as a constituent interest of the United States Steel Corporation in January, 1906, and the subsequent announcement of its plans for the building of a steel plant of unprecedented size at Gary, Ind., this undertaking has commanded the interest and attention of the entire industrial world. Nor is this due alone to the magnificence of the scale upon which the work was planned; for it was easily recognized that an unprecedented opportunity would be here afforded for a concentration of the most modern methods and appliances for making steel from the ore to the finished product.

Projected under conditions unhampered by the limitations of capital and favored by the acquisition of an adequate site, it was expected—and with good reason—that the Gary plant when completed would represent in all of its units, individually and collectively, the acme of achievement in this branch of the world's industries. And as the plans have developed and taken form in construction, no doubt remains that these expectations are in the end to be realized in the fullest degree. The opportunity of designing a complete steel-making plant of such size has never before presented itself to engineers; nor indeed can conditions better suited to successful accomplishment be easily conceived. The history of steel plant construction, in this and other countries, has been, generally speaking, one of evolution from more or less modest beginnings. First plans for such enterprises usually make only imperfect or inadequate provision for future growth and extension, with the result that there are lacking the perfect symmetry and complete co-ordination of parts which are only possible when ultimate ends are in the view from the beginning. Here, however, is a great, well balanced plant, which will finally comprise a system of component units fitted together in a related plan calculated to facilitate, at every stage, the production of steel, and to secure the maximum of economy in the cost of producing it.

When, in consideration of the large and rapidly growing consumption of steel products in the Middle West, it was decided to locate the proposed plant centrally in that region, three factors of prime importance were to be considered in the selection of a site: First, there was required a lake harbor with a depth of water sufficient to accommodate the largest vessels of the ore fleet; second, adequate rail transportation facilities were imperative, and finally a tract was needed of large acreage and moderate value, in one body, so located as to include the first two requirements. These conditions seemed to be fully met in the uninhabitated waste of sand dunes on the southernmost shore of Lake Michigan in the northern end of Indiana, where, after due investigation, a tract of land embracing more than 9,000 acres was purchased and the work of construction started.

Owing to its remoteness from other habitable centers, it became necessary to provide dwelling places for the employees, and the building of a city was added to the original undertaking. The city of Gray was therefore laid out, just south of the steel works, upon an orderly plan and comprehensive scale, taking into account its probable growth to metropolitan proportions. Already Gary has an estimated population of 15,000 before the plant has fairly started, and is provided with an adequate waterworks system, whose permanent water supply will be drawn from Lake Michigan through a tunneled intake now under construction; an electric lighting plant, an electric street railway and a complete sewerage system. Its main street, paved with brick and concrete, has its northern terminus at the entrance of the steel plant, where the company's three-story brick administrative building and

FIG. 1.—VIEW FROM THE SIDE BAY OF THE BOILER SHOP, LOOKING INTO THE CENTRAL BAY ON THE RIGHT.

*Abstract from an article on "The Greatest Steel Plant in the World," in the *Iron Age*.

hospital buildings, yet to be erected, will face each other on either side of the street.

When first acquired by the Steel Corporation, two lines of road, the Baltimore & Ohio and the Chicago, Indiana & Southern, ran through the center of what is now the mill site. Over 40 miles of new railroad was built, and both the above roads were re-established by the corporation on rights of way passing between the town and the mills. The tracks at this point are elevated, to allow an unobstructed entrance to the works.

The boiler shop of this immense plant is 133 by 160 feet, with a height of 43 feet 4 inches from the floor to the roof chords in the main section, which is 63 feet wide. The plan and section are shown in Figs. 2 and 3. In addition to a 15-ton traveling crane covering the center bay, of which a view is given in Fig. 1, there are a number of wall cranes serving the principal machines.

The tool arrangement is designed to promote a continuous order of operations. Entering the shop at the east end over the switch track, or brought in on the tram car from the stock yard on the south side, material passes first to the shears and thence to the punches on one side, and from there is carried over by crane to the bending rolls and forming machines on the other side. A clearance of 25 to 30 feet between the swing of the jib cranes affords space through the center of the shop for riveting and erecting work. The side bays, each 35 feet wide, are utilized for laying out and fitting and for lighter work.

Compressed air for the operation of pneumatic tools is supplied by an Ingersoll-Rand twin compressor, driven by a 120-horsepower Westinghouse synchronous motor. A heating and ventilating system similar to that in the machine shop provides an even and comfortable temperature throughout the shop.

The term boiler shop as applied to this department is somewhat a misnomer, since the boiler work required about the plant is relatively small, gas superseding steam as a means of generating power service, heating and other miscellaneous requirements, so that there are comparatively few boiler units in actual operation. Of these the yard locomotive boilers comprise the greater number. All of the stationary boilers about the plant are of the watertube type, and the repair work incident to their maintenance calls for but little boiler work in this shop, which is now more commonly referred to as the structural shop. Prior to the starting of the blast furnaces, and later the open-hearth furnaces and rail mill, it was chiefly employed in getting out miscellaneous structural jobs in connection with construction of the various plant buildings. It will, however, as plant operations extend, be largely employed in the repair of ladles.

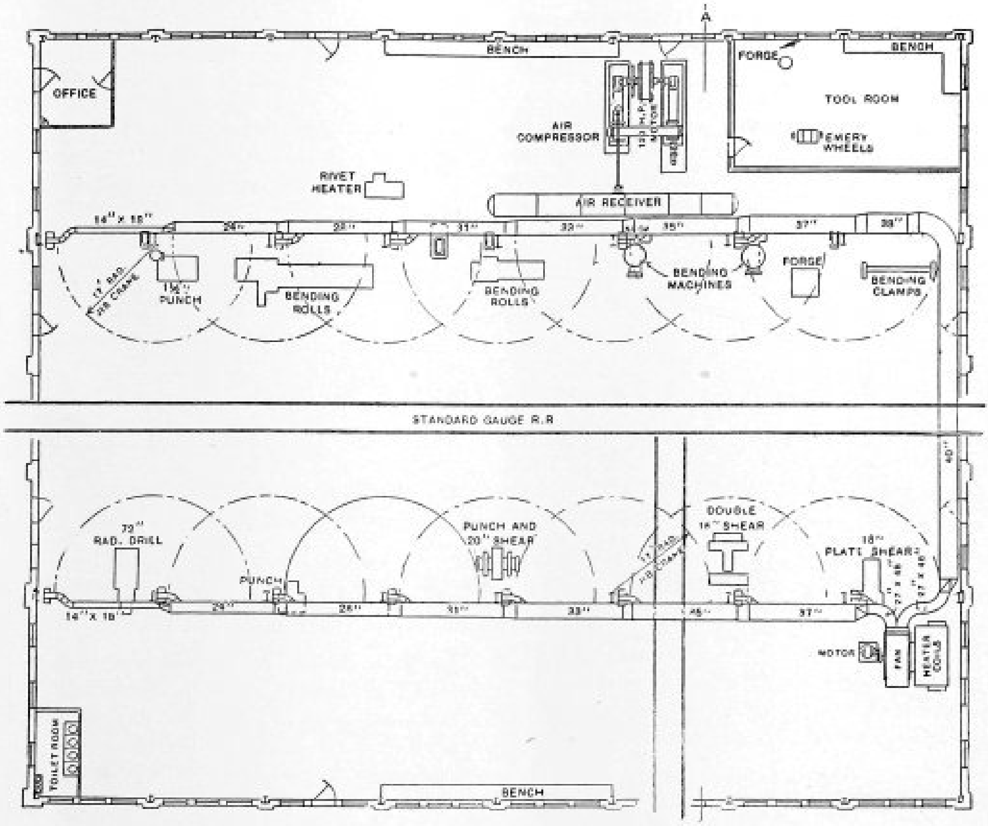


FIG. 2.—PLAN OF THE BOILER SHOP AT THE GARY STEEL WORKS.

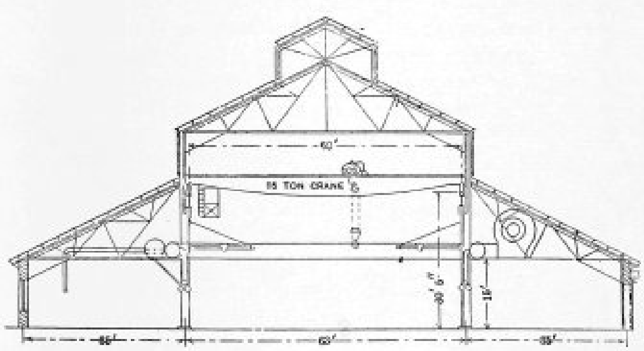


FIG. 3.—TRANSVERSE SECTION OF BOILER SHOP THROUGH A-A, FIG. 2.

Its tool equipment is adequate for a wide range of heavy work in plates and structural construction, being equal to any demands likely to be imposed upon it either in repairs or new construction. Extraordinary care has been exercised in providing safeguards against accidents likely to result in personal injury to workmen through contact with machinery. Gear wheels and other moving parts of all tools are, as far as possible, completely inclosed in metal shields. There are no line shafts in the shop, each tool being driven by an independent motor mounted upon the machine itself.

MARINE BOILER REPAIRS BY THE OXY-ACETYLENE PROCESS.

BY JAMES CROMBIE.

A large repair job, one that will be watched with great interest by boiler makers and shipowners, has just been finished on the steamship *Spray I.*, belonging to Messrs. Ellis & McHardy, Aberdeen, Scotland. The repairs were undertaken by John Lewis & Son, boiler makers and engineers, Aberdeen. This enterprising firm has installed a welding outfit, and has already completed repairs on several steamboats by this process.

The *Spray I.* has one large boiler of the Scotch marine type, the boiler being about 15 feet diameter, and having three furnaces, each 3 feet 6 inches diameter and ¾ inch thick. The boiler has been in service eighteen years.

The lower front-end plate, which is ⅞ inch thick, was cracked along the knuckle or turn of the flange at the center furnace hole, and a patch had been put on two years previously. Owing to the crack extending beyond the patch it was necessary to take out the end plate and renew it, or to weld up the cracks, which had now assumed serious proportions, the center furnace hole being cracked almost entirely around the circumference. At the bottom of this furnace there was a crack running from the plate edge inwards about 7 inches; at the back end of this same furnace, in the fire-box, the flange was bad. Both wing furnace holes were cracked at the turn of the flange and required welding.

It was decided to weld up all the cracks, and the patch at the center furnace was cut off, leaving twenty-nine holes in the front-end plate and twenty-five holes in the furnace tube to weld up, each hole being 15/16 inch diameter. The cracks were all prepared for welding, and were scarfed or grooved out with a round nose or cape chisel nearly the full thickness of the plate. The cracks, as already mentioned, were on the turn of the flange, and at the center furnace hole there was a total of 11 feet to weld up. One wing furnace hole was cracked nearly three-quarters of the circumference, and the opposite wing furnace had a crack about 16 inches long. In the center fire-box the furnace flange would require about 3 feet at one side and 1 foot at the opposite side to be cut off and renewed; this plate being ¾ inch thick. Owing to the landing at this point having been frequently chipped and calked and leaking again, the adjacent plate was grooved and thin close up to the rivet holes. This thin part was filled up to the full thickness of the original plate by welding on the metal with the oxy-acetylene burner; the surface was then trimmed with a flat chisel, to allow the surface of the new plate to lie close and form a good joint. The new pieces of plate were then fitted into place, the edge of the old plate and the adjoining edge of the new plate being beveled for welding; the pieces were then bolted up and welded, and afterwards riveted and calked.

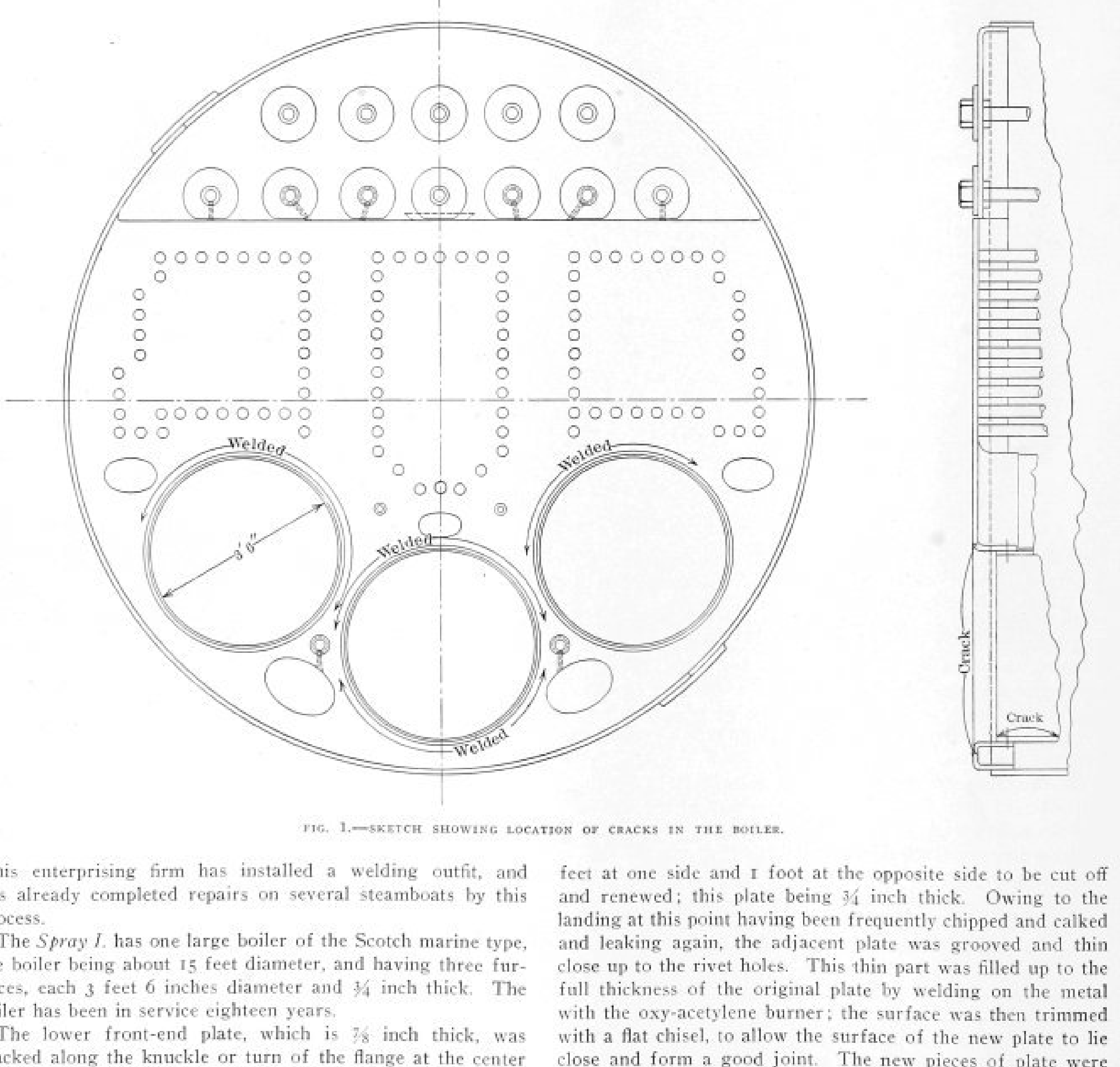


FIG. 1.—SKETCH SHOWING LOCATION OF CRACKS IN THE BOILER.

Two burners were employed for all the operations, one burner was used inside the boiler to heat the plate, the second burner doing all the welding; this kept the heat up through the entire thickness of the plate, thus ensuring a perfect weld. When the groove was filled up, or welded, to the full thickness of the plate it was given a few blows with a hammer, a man holding on inside with a heavy hammer.

In welding up the old rivet holes, which were 15/16-inch diameter, through ⅞-inch plate, the holes were welded from the inside of the boiler first, starting as far through the hole as possible and filling it up. The hole was then finished from the outside of the boiler, the man inside the boiler first bringing the new piece up to a bright, red heat; the welder then brought his jet into play, and gradually filled the hole up a little more than flush with the plate; both burners then played for a few seconds around the welded part, and then a few

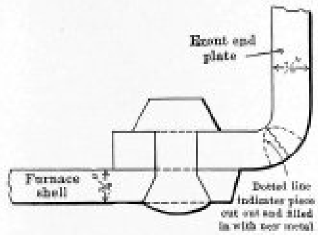


FIG. 2.—SHOWING METHOD OF FILLING AND WELDING CRACKS.

quick blows with a hammer completed the operation, leaving a nice, solid plate. For welding, Swedish iron was used about 3/16-inch diameter.

The oxygen and acetylene gases were supplied in cylinders, so there was no charging and cleaning out of an acetylene generator. The writer believes that the cylinders are the safest way in which the gas can be stored for this class of work, as in the confined space in a stokehold accidents are very liable to happen with the acetylene generator, as they are not fool-proof.

A portable pneumatic plant was also employed on this repair job for drilling, etc. A compressor with motor drive was stationed in a punt which was moored alongside the vessel being repaired. Current was supplied from the power line at the quay side.

On the completion of the repairs the boiler was subjected to a hydrostatic test of 250 pounds per square inch, and everything was tight. Steam was then raised to 160 pounds, everything being satisfactory.

Needless to say, the repairs were closely watched by Lloyds and by the Board of Trade inspectors at Aberdeen, and owing to the size of the job Messrs. Lewis & Sons engaged Mr. J. Kennedy, who is said to be one of the foremost experts on the oxy-acetylene process in Great Britain, to supervise the work.

The *Spray I.* is engaged in the coal trade and makes short trips, the main boiler fires are banked while in port, and a donkey boiler is used for steam for discharging the cargo. The steam pressure on the repaired boiler therefore varies quickly, and this will give the repairs a thorough test, and will go far to prove the value of this process of making repairs on a large scale where boilers are subjected to the severest conditions.

Boiler makers who object to the scale of wages in some of the shops in this country should remember that in Japanese shipyards boiler makers are paid an average wage of only 98 cents per day, ten hours being the average working day. Some very creditable work is turned out in Japanese boiler shops, too.

THE YORKSHIRE BOILER.*

BY W. H. CASMEY.

Our capabilities are unequal up to the present of securing full value from the heat liberated in boiler furnaces because of our imperfect methods of utilizing it. From our boilers and economizers, if we have everything in good condition, we may secure 70 percent of the heat generated, while 30 percent is thrown away as wasted energy. Between the boiler and engine 5 percent or even more of the 70 percent is lost from conduction, etc., and the turning of heat into work by the engine reduces our power from 40 to 45 percent, so that, approximately, we do not, under the best conditions, receive as useful power the heat contained in more than from 18 to 20 tons out of every 100 tons burned.

We secure, under ordinary conditions, from 60 to 70 percent efficiency from our steam-generating plants. Our chief loss occurs in turning the steam into useful power, and as very great difficulties present themselves in improving to any extent our steam engines, any improvement we can secure on the boiler is net gain. As an illustration of this point one Yorkshire firm, whose coal consumption was 2 pounds per horsepower-hour, reduced the consumption to 1.8 pounds by installing new boilers, and as the firm in question have 2,000 horsepower, the saving effected equals 400 pounds of coal per hour, or, for a week of 55 hours, a saving of nearly 10 tons of coal, which at $2.53 per ton, allowing two weeks for holidays, amounts to $1,250 per year. This saving is effected by improving the efficiency of the generating plant 10 percent.

There are four important points to be considered by anyone intending to put down a steam plant: (1) The composition of fuel, and how the heat liberated during combustion is transferred to the boiler; (2) the most economical speed at which furnace gases should travel; (3) the transmission of heat and its effect on different parts of the boiler; (4) the law of ebullition.

With regard to the first, the proportion of carbon is the chief consideration, as it is principally owing to its chemical union with the oxygen of the air that heat is generated. Average British coal contains about 80 percent of carbon. The heat from the fixed carbon or coke is given off radiantly, and, therefore, to that portion of the boiler plates located between the doors of the furnaces, and within, say, 3 feet from the bridges and from the underside of the fires to the ash-pit. The greater the fire area the more heat is lost by radiation, and the more danger of excess air getting into the flues. The gaseous portion of the fuel is carried along the flues as flame or smoke to an extent dependent entirely on the management of the fires. Practically 60 percent of the total heat generated in the furnaces is thus given up to the first 8 or 10 lineal feet of the boiler or lost in the ash-pits, and the remainder is distributed over the rest of the boiler and used up in producing the draft, the percentage of heat required for the latter purpose being from 15 to 20 percent of the total heat convected or carried heat. To get full value from the heat liberated during combustion, boilers should be built in such a way that the water and heat are equally distributed between the two end plates.

Second, the speed at which the gases travel along the flues is a subject on which little appears to have been written, and the main consideration with the general engineer is an air velocity under the ash-pits of about 700 feet per minute, irrespective of the quality or quantity of the fuel used. As an illustration, the area of the two grates in a 30 by 8 feet 6-inch Lancashire boiler is 41 square feet, and burning 30 pounds of coal per square foot, or a total of 1,025 pounds per hour, and allowing 20 pounds of air per pound (an excess of 60 percent over the theoretical quantity) a furnace temperature of about 2,300

* From *The Mechanical Engineer.*

degrees F. would be obtained. Under these conditions, the velocity of the air under the ash-pits should not exceed 320 feet per minute, and this volume of air would expand during combustion about four and a half times, so that immediately after the bridge was passed the velocity would be about 1,300 feet per minute, and this would be gradually reduced as the gases contracted, due to the heat taken from them by the water, to about 900 feet per minute at a point 6 feet from the rear end, where the temperature would be about 1,300 degrees F. Here, however, due to the reduced area of the flues, the velocity would be mechanically increased again to over 1,300 feet per minute. This boiler, when supplied with 20 pounds of air per pound of coal, evaporated 8 pounds of water per pound of coal burned, or a total evaporation of 820 gallons per hour. If the same weight of coal is supplied with double the quantity of air, as indicated by a velocity of 700 feet per minute through the ash-pits, the extra volume of air has to be heated, and reduces the temperature proportionately, and it would then stand at 650 gallons per hour instead of 820 gallons. We should always bear in mind the temperature of combustion is constant—in fact, cannot vary, and remains the same whether burning 20 pounds or 60 pounds of coal per foot of grate, and our fuel losses are caused by allowing too much air to enter the furnaces, thereby reducing the temperature of the gases by dilution, or if too little air is supplied for completing combustion, losses follow. Fuel burned to carbonic acid gas equals 100 percent of its heat value, but if only to carbonic oxide, 35 percent.

Third, the law of heat transmission through a boiler plate is governed by the speed, temperature, and density of the hot gases, but is otherwise as stable as the law of gravitation, and it is this fact which makes us wonder why its effect has not been considered seriously years ago, as it contains the key to the whole situation and proves the absurdity of long boilers. We have just learned the temperature of combustion is constant and remains the same whether burning 1,000 pounds of coal per hour or 2,000 pounds, and if the air supply continues proportionate, the density of the gases will also be the same. If we examine this point carefully we shall find that doubling the hourly consumption of coal also nearly doubles our evaporation, and as our fires are still the same temperature this increased evaporation can only be secured by sending the gases through the boiler flues at double their original velocity. We have often noticed with induced draft we can raise more steam than by natural draft, and generally it is said to be due to a higher furnace temperature. It is, however, nothing of the kind, but entirely due to the fact that the fan causes the gases to move more rapidly along the flues, and the higher velocity acting on the boiler plates produces increased transmission of heat.

Fourth, our last consideration is ebullition; that is, when the water is dancing rapidly round the furnace flues. Sir William Anderson and Sir Ed. Bramwell carried out a long series of experiments so far back as 1872, which conclusively prove that when a boiler flue is surrounded by boiling water it will only transmit two and a quarter times as much heat as when such flue is surrounded by still water. The modification of the Lancashire boiler, which has proved itself worthy of the title, the "Yorkshire" boiler, is generally shorter than the Lancashire in proportion to its diameter, and its two flues rise slightly from front to back and expand from the end of the furnaces to the down-take in the proportion of 2 to 3; that is, the sectional area of the flues at the rear is 33 percent greater than at the front. This has the effect of causing the bulk of the water to be located directly over the points where the large proportion of heat is transmitted to the boiler. Over the furnaces there is 6½ inches greater head of water than at the rear end of the boiler. This equals, in the first 8 feet of a 9-foot boiler, 2,400 pounds. The total heating surface and fire grate of the "Yorkshire" boiler is reduced as compared with the Lancashire boiler, but its effectiveness is so much improved that the total evaporation is considerably increased for reasons just given.

The object of expanding the flues is to produce a more uniform transference of heat to the water over the whole length of the boiler, since the temperature of the products of combustion gradually lowers the further they travel away from the furnaces, while the expanding, or enlarging section, presents a larger heating surface, and the body of water surrounding them suffers a corresponding diminution. A greater proportion of heat is thus abstracted at a distance from the fires than where the flues remain of the same diameter, and as this heat is abstracted by a smaller quantity of water, a higher temperature is given to the water at this point. By slightly inclining the flue from front to back, the head of water over the hottest part of the flues is unusually large, and this increases the rapid circulation and tends to restrict the downward currents on the outer side of the flues. With the ample passageway towards the front end of the boiler the longitudinal unrestricted circulation is increased and assisted by the greater upward pull immediately over the furnace, due to the bigger head of water.

The four facts laid down at the beginning of this paper we will now further consider, and see how far they apply to the new boiler. From 60 to 70 percent of the heat of our fuel, we learn, is transmitted to the boiler in the first 6 or 8 lineal feet. This indicates at once the larger proportion of water should be over the furnaces. Our second item was speed of the gases. The flues of the "Yorkshire," by expanding towards the rear, and apart from this, also having a slight upward inclination, cause the velocity of the gases through the front and smaller portions of the flues to be very rapid, thus securing at the front, where the larger head of water is located, the greatest transmission of heat. The expansion also gives at the rear of the boiler, where the temperature is lowest, the largest area of heating surface and the minimum head of water, and this expansion of the flues and the upward inclination further assist in maintaining the velocity of the gases, the total results being that the heat and water are proportionately distributed throughout the boiler, hence more work is done by the smaller furnaces and heating surface.

A practical proof of this will not be out of place. When burning 1,000 pounds of coal per hour in a Lancashire boiler 30 feet long, the temperature of the gases at the down-take was 1,305 degrees F.; burning 1,000 pounds of similar fuel in a 20-foot "Yorkshire," with the same chimney draft, the temperature at the down-take was 1,115 degrees F.; that is, the gases at the end of the 20-foot flue were 190 degrees lower than at the end of the 30-foot flue. This proves that the smaller boiler absorbed 10 percent more heat than the larger one, and we have previously seen this amounts to a saving in fuel of about $300 per boiler per year.

The laws of heat transmission and ebullition, our third and fourth points, fully explain the foregoing. The whole flue area of the shorter boiler being active, transmits two and a quarter times as much heat per square foot as the latter two-thirds of the longer boiler. The first 6 lineal feet of a "Yorkshire" boiler, 20 by 8 feet 6 inches, contain 1,560 pounds more water than the first 6 lineal feet of a Lancashire boiler of the same diameter, and the last 6 lineal feet of a Lancashire boiler contain 930 pounds more water than the last 6 feet of a "Yorkshire" boiler; and to carry this into more detail we find that in the first 6 lineal feet of the "Yorkshire" 1 square foot of heating surface is provided for every 252 pounds of water, and at the rear 1 square foot for every 90 pounds; in other words, as much heat is given to 252 pounds of water at the front as to 360 pounds at the rear. In the Lancashire, 1 square foot of heating surface is given to every 172 pounds of water at the front, and 1 square foot for every 106 pounds of water at the rear, or the same heat is given to 172 pounds at the front as to 424 pounds at the rear; uniform steaming is therefore impossible.

The first "Yorkshire" boiler was designed to give an evaporation of 8,000 pounds of water per hour from a feed of 180 degrees F. It is 20 feet long, and has 712 square feet of heating surface and 33 square feet of grate area, the ratio being 21 to 1. It was put under steam in July, 1907, and when evaporating from 8,000 pounds to 9,000 pounds of water per hour, its efficiency is 70 percent, and if the fuel used has a calorific value of 13,000 B. T. U. per pound, the evaporation per pound of coal is 11 pounds of water, or an efficiency for boiler and economizer of 81.8 percent. This boiler has, owing to a breakdown to a Lancashire battery, carried a load of 900 horsepower (15 pounds of steam per indicated horsepower) for three days successively, and which equals 13,500 pounds of water per hour, but even this evaporation does not give its best work.

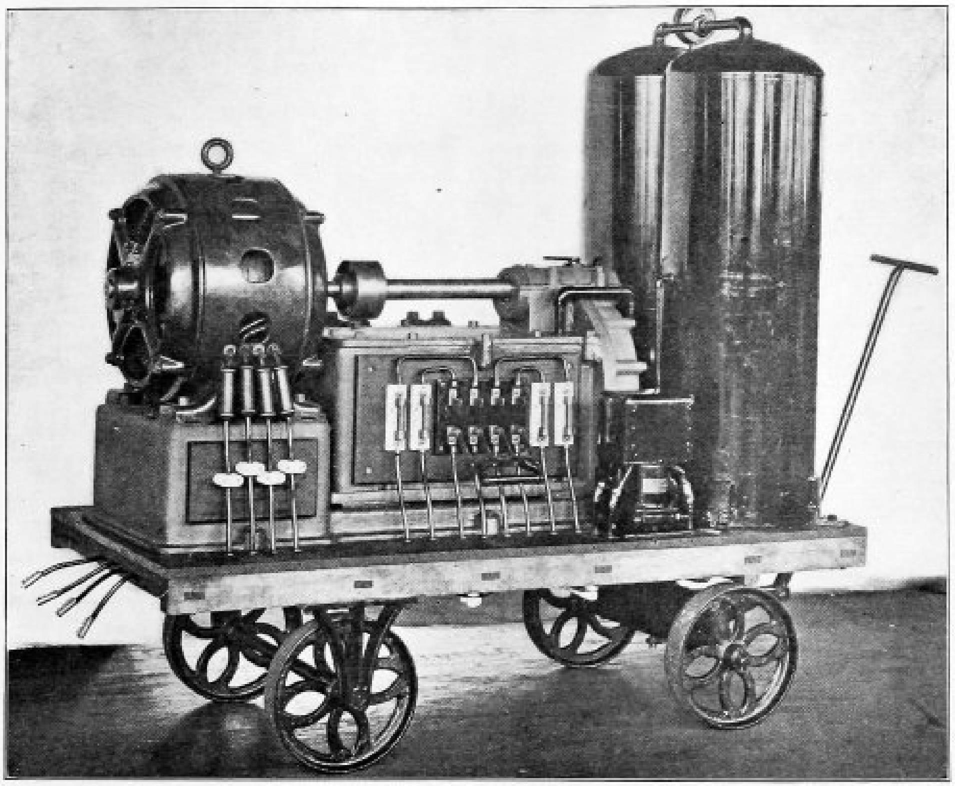
In August last a test, made by an independent authority, for one day gave an evaporation of 13,805 pounds of water per hour, and for the sake of seeing what the boiler would do for the last hour of the test, the dampers were opened wide and the stokers speeded up. The result was an evaporation of 15,000 pounds of water during the hour, which equals over 21 pounds from a feed of 96 degrees F. per square foot of heating surface, or equivalent to an evaporation of 18,400 pounds from and at 212 degrees, which equals 25.7 pounds per square foot of heating surface.

Summarized, the advantages of the "Yorkshire" boiler over any other of the cylindrical type are: Lower first cost, higher efficiency and evaporation, less ground space and brickwork required, which means a further reduction when installing a boiler, the total amounting to nearly $500 per boiler; conduction and radiation losses one-third less than in the Lancashire boiler for the same evaporation. Finally, as the "Yorkshire" boiler is shorter and distributes the heat and water proportionately, the expansion and contraction will be much less, cross strains avoided, and the life of the boiler consequently lengthened.

A Unique Portable Electrically Driven Air Compressor.

BY FRANK C. PERKINS.

In mining service as well as in construction work compressed air is extensively employed for driving pneumatic drills and other similar apparatus, in many cases to better advantage than by other similar apparatus driven by electric power. Similarly, in steel construction work, such as the erection of stacks, tanks, bridges, buildings, etc., a compressed air plant for drilling, reaming and riveting is a necessity. In many cases electric power is available, and a portable air compressor can be utilized to better advantage than a steam-driven or gas engine-driven compressor.



GENERAL VIEW OF PORTABLE, ELECTRICALLY-DRIVEN AIR COMPRESSOR.

The illustration shows a new alternating-current, electrically-driven portable air compressor, which allows the use of pneumatic tools and other apparatus with such advantages as they may have, at the same time taking advantage of the economical electrical transmission of the power instead of the wasteful and cumbersome piping necessary for air distribution on the pressure, while more flexible for changing location where the power is to be used. This electric compressor is provided with two air tanks on the same truck with the motor. The starting switch and electric regulator can be seen in the foreground mounted on the compressor case, with the electrical connections for couplings to the power table at the left.

Stay-bolts of electrolytic copper have given bad results in locomotives on Prussian railways during the last few years.

Self-Cleaning Ashpans on the C. and O. R. R.

BY G. W. SMITH.

Since there are nine or ten different classes of engines on this road, I will deal with only two different classes. Fig. 1 is a pan for a passenger engine, No. 100. The dampers are omitted; the sides of the pan are perforated or punched out, and a netting is applied as shown. Fig. 2 is a drawing of a C-2 class or switch-engine ashpan. The slides on this pan are coupled together, and are operated from the left side of the engine, as in Fig. 1. Fig. 3 is a detail drawing of the casting and slide used on all classes of ashpan on the road. Several of the engines have been equipped with the self-cleaning pan, and are giving excellent service. The bottom casting and slide are cast steel and will last indefinitely.

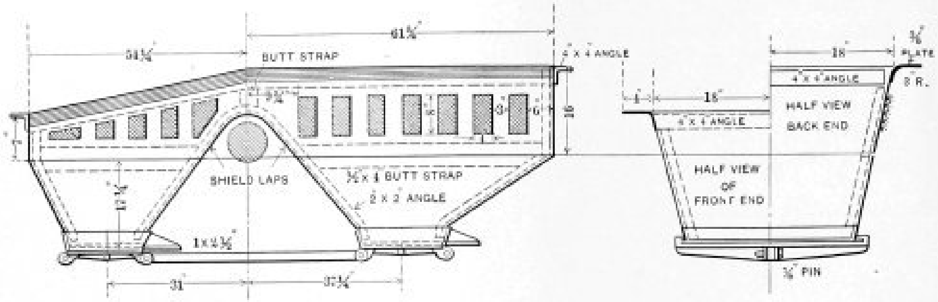


FIG. 1.—SELF-CLEANING ASHPAN FOR C. AND O. PASSENGER ENGINE.

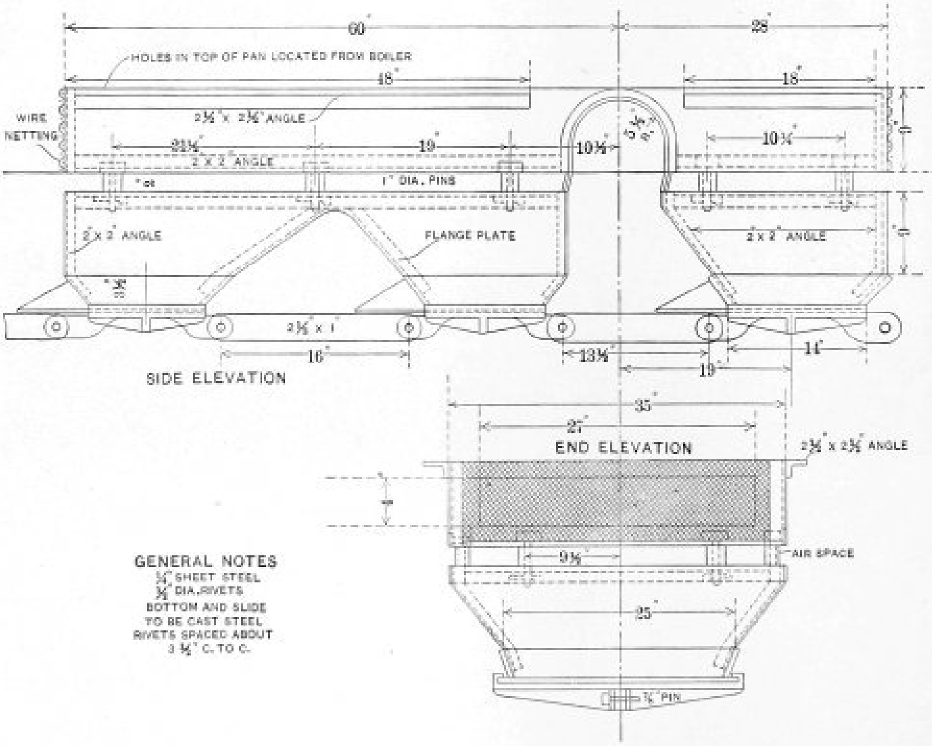


FIG. 2.—ASHPAN FOR SWITCH ENGINES.

Scientific Boiler Control.

At the Institute of Marine Engineers, Stratford, England, recently a lecture was given by Mr. G. A. H. Binz on "Scientific Boiler Control." After remarking upon the large amount of waste, even with experienced firemen, due to the usual methods of stoking, Mr. Binz advocated as a remedy a continuous and automatic analysis of the products of combustion which would indicate the method of stoking that produced the best results. The carbon in the coal, he said, was not always burned to CO_2, it might be changed only to CO, or any particle of CO_2 might be retransformed into CO if it should, in its passage through the firebed and flues to the chimney, come in contact with atoms of highly-heated carbon. The proportion in which these two gases were present in the furnace gases could only be determined by chemical analysis. A pound of dry carbon burned entirely to CO_2, gave heat equal to 14,600 British thermal units, whereas the same weight of the same carbon burned to CO only yielded 4,450 British thermal units. It therefore followed that if there was a low percentage of CO_2 in the exit gases a lot of the heat was lost, and, inversely, a high percentage of CO_2 denoted good combustion. This percentage could be ascertained by means of a CO_2 recorder, an instrument which produced, practically automatically, a certain number of records per hour of at least one of the products of combustion. There were two factors to be considered in estimating the CO_2 contents of the exit gases; the presence of CO when the percentage of CO_2 was high and the temperature of the gases at the stack. As CO was a heat absorber it was obvious that it would be of little use to produce a set of conditions which, while securing a high percentage of CO_2, also had a tendency to encourage the presence of CO in appreciable quantities, but the admission of air was all that was necessary to prevent this initial formation. The possibility of the transformation of CO_2 back to CO was very remote, as long as the percentage of CO_2, as shown by the recording instrument, was not more than 14 to 15 percent, and the formation of CO under those conditions was most probably due to a low velocity of the gases in the furnace at a high temperature, which encouraged contact of particles of CO_2 with highly-

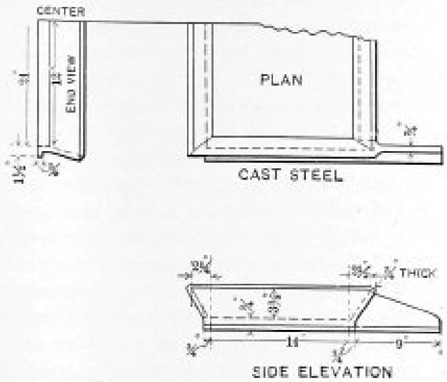


FIG. 3.—BOTTOM CASTING OF ASHPAN.

heated carbon. A high temperature at the stack was due either to conditions unfavorable to complete combustion of the fuel and the gases given off by it immediately over the grate, or to too high a draft pressure. The results in the former case would be shown on the recorder, but in the latter case it was advisable to take into consideration the tempera-

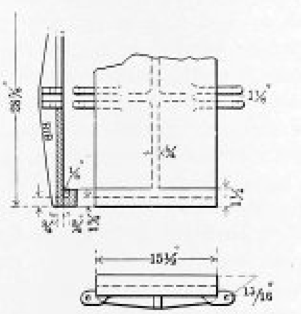


FIG. 4.—SLIDE.

ture of the exit gases in addition to the percentage of CO_2. If an engineer could, by the use of a CO_2 recorder, increase the percentage of CO_2 in the exit gases from 5 to 14 percent it would effect a saving in coal of 21½ percent, and if, in addition, he succeeded in reducing the temperature at the stack by 100 degrees, the saving would amount to 24 percent.

BOILER PRACTICE IN EUROPE.

A recent report to the International Railway Congress, published in the *Bulletin*, takes up the subject of locomotive boiler practice in Belgium, Spain, France, Italy and Portugal, and gives some details showing the tendencies that are predominant in these countries. In comparing them with the practice of the United States, many familiar things will be seen, and yet it is curiously interesting that the European engineers seem to be having difficulty with details that have been established in America for years, and have given the best of satisfaction. This is especially true of the use of steel in fire-boxes, which is just now coming to gain a real foothold. That trouble has existed does not seem to be wholly due to the possible fact that the best method of application was not known, or a suitable quality of steel was not used, because in some American-built locomotives, delivered to the Italian State Railway, it was stated that the results were not satisfactory. Still, we all know that the personal equation of likes and dislikes has much to do with the success or failure of a device or practice in this country, and there is no reason to think that this should be different abroad.

As a general rule, the fire-boxes are of copper, but a number of trials of steel are in progress. The Nord, of France, has lately fitted two locomotives of the older design with fire-boxes made wholly of steel, but the application has not been in service for a sufficient length of time to make it possible to draw conclusions as yet.

The Midi has fitted a considerable number of locomotives with steel crown sheets, and they are said to be giving good satisfaction. On the other hand, the Paris, Lyons & Mediterranean used some steel fire-boxes a number of years ago that were discarded as unsatisfactory because of the cracking of the stayed portions.

During the past two years the French government system has been trying a composite fire-box on two locomotives that are carrying pressures of 185 pounds and 213 pounds, respectively. In these, that part of the tube sheet that receives the tubes is made of steel, and the lower part of copper. These two parts are joined by a lap seam with the copper part towards the fire, so that the seam can be calked, and this is located just above the arch. These compound plates have, up to the present, given good results; leaks have, however, occurred at the seam which have been stopped by calking, and this has made it necessary to replace some of the rivets. Finally, the Great Southern of Spain has had two boilers fitted with steel fire-boxes for the past two years and these are reported as giving good satisfaction. So it appears as though the steel fire-box was at last gaining a foothold in these countries and that in time it will drive out the copper construction, just as it has in the United States.

The types of boilers used are divided between the Belpaire and the radial stay. The French railways are using the Belpaire on the greater portion of their work, but this holds for only a portion of the Belgian State Railway, where the Belpaire boiler originated, as these lines have only a few compounds with that type. The Spanish and Portuguese systems use both types and so also do many of the secondary railways. Taken as a whole, however, it is the radial stay boiler that is the most extensively used. The use of crown bars has practically disappeared and they are only used on a few of the secondary lines. The advantages of the stay in the matters of lightness, ease of repairs and inspection and cleaning have been the controlling factors in the adoption. The practice of using one or more rows of expansion stays at the front is recommended as a relief to expansion stresses, and is the common practice. Attention is called to this in connection with the discussion at the last convention of the Master Mechanics' Association, in which many doubts were expressed as to the utility of this form of stay.

As for the cylindrical fire-boxes that were introduced into the United States several years ago, after they had been tried and discarded on the West Bank of the Rhine Railway, the simple statement is made, in the report, that they are not used at all, and the fact that after several years of use they do not seem to be gaining any great headway in the United States indicates that the theoretical advantages are greater than the practical, which, as in other things, is bad for the theory.

Firedoor practice naturally varies, and there is no definite shape that is anything like a universal practice. A hinged door is, however, in universal use, but the shape runs from the round through the elliptical to the almost square. In the construction of the opening the two sheets are always connected by a riveted ring.

The relations between the grate area, air space in the fire-grate, as well as the total tube area, are taken up at length. The air spaces in the fire-grate are, as a rule, equal to about half the total area of the grate; on some railways this ratio varies between one-half and two-fifths; in some cases it is reduced to 0.35, particularly if rocking grates are used. This type of grate, which is very common in America, is beginning to become more usual in Europe; the Orleans Railway has adopted it on its more recent locomotives and so has the French State Railway; the Midi and the Paris-Lyons-Mediterranean have equipped several locomotives with this device as an experiment. Rocking grates seem to give very good results; they make it easy to clean the fire while saving the fireman from the troublesome handling of the firing tools.

The total clear cross-section of the smoke tubes varies between a sixth and an eighth of the grate area. This cross-section can hardly be too large; increasing it reduces the speed of the current of hot gases and consequently reduces the amount of fuel (solid or gaseous) which is drawn over into the smoke-box without being burnt. The clear cross-section can be increased either by increasing the diameter of the tubes (for it is easy to see that with a given area of tube plate, the cross-section of the tubes is increased by increasing the diameter), or by adopting the American "wagon top" form, by means of which the tube plate of the fire-box can be given a greater useful surface, better proportioned to that of the tube plate of the smoke-box.

The heating surface of the tubes varies between fifty and seventy times the grate area, if smooth tubes are used, and between sixty and eighty times the grate ara, if Serve tubes are used. Increasing the heating surface of the tubes to beyond a certain limit (which, in the case of smooth tubes, can be fixed at about fifty to sixty times the grate area), is of a very little advantage as regards the efficiency of the boiler. In fact, even if the heating surface of the tubes is very much increased, all that can be attained is to reduce by some 50 degrees, that is by one-sixth at most, the temperature of the hot gases in the smoke-box, which varies normally, according to the intensity of the combustion, between 570 and 660 degrees F. Now the heat lost by the gases in the smoke-box represents about 15 percent of the total heat produced by the combustion of the fuel. If this loss is reduced by one-sixth, the amount of heat utilized, that is to say, the efficiency of the boiler, is only increased by 2.5 percent.

Generally speaking, except in the case of Pacific locomotives which are as yet few in number, the length of the barrel does not exceed 16 feet 5 inches. The smoke-box is rigidly fixed to cross-bracing connecting the frame plates. On some railways the barrel has no other support, but most of them use intermediate supports, which are formed either of flexible plate, according to the American plan, or of cross-bracing formed of steel castings, on which the boiler can slide. The plan is adopted, and with still better reason, on the Pacific locomotives, which have barrels about 19 feet 8 inches long.

It may be asked whether, in the case of long boilers, the tubes, which are subject to vibration and to bending, do not require to be supported by an intermediate tube plate. This has sometimes been done in the case of old locomotives, but it has been found to be useless. This uselessness is very definite if ribbed tubes are used, which are very stiff; smooth tubes having a greater outside diameter than 2 inches are also sufficiently stiff, and there is a tendency to use, in the case of long boilers, tubes having a diameter of at least 2⅛ inches.

Nearly all the railways use a drum-head tube plate in the smoke-box; this is riveted to the inside of the front ring of the barrel. Some, especially the Belgian State and the Andalusian, also use a plate with extension fitted to the barrel with an angle.

In the matter of the material for the tubes there seems to be a tendency to adopt iron or steel with a probable preference for the latter material. This does not mean that the brass tube is disappearing. Mild steel is being extensively used in France because it is cheaper than brass and produces a lower strain on the tube sheets because of the lower coefficient of expansion. Then, too, it has been found that brass tubes do not resist a pressure of more than 170 pounds satisfactorily, while the fire-box ends of such tubes are corroded very rapidly. At the same time it is acknowledged that steel tubes become corroded and pitted more quickly than brass if the water is bad; but, as a general rule, the water in France is good. Algiers, Italy and Belgium, on the other hand, still cling to the use of brass, though Italy is using iron or steel for long tubes. In Belgium the action of the expansion is avoided by giving the tubes a slight upward curvature and by the use of stays between the tube sheets.

It is, of course, well known that the weights of locomotives and consequently of the boilers is less in Europe than in the United States, which results in a shorter length of tube than that which has almost come to be considered as normal here. The Serve tubes, which have been used nearly exclusively on the French locomotives during the past ten years, have a length that varies from 11 feet 6 inches to 14 feet 9 inches. But some of the recent Pacific locomotives that have been built have tube lengths of 19 feet 8 inches, and these have an outside diameter of about 2¼ inches. The external diameter of the Serve tubes is usually from 2 9-16 inches to 2¾ inches. The older locomotives, having smooth tubes, seldom have lengths above 16 feet 5 inches, with an external diameter of about 2 inches, which corresponds very closely with the practice in America.

In the application of the tubes they are sometimes contracted as much as 5-32 inch at the fire-box, and expanded ⅛ inch at the smoke-box.

The Serve tube is used almost exclusively on the French lines, and it is also used extensively on the Italian roads, but, while it is generally recognized as giving good results in steam generation, there are a number of roads, such as the Eastern, Midi and Italian State, where it is considered as causing rapid deterioration of the plate because of its rigidity.

In 1896 the Belgian State Railway tried Serve tubes on a number of Belpaire boilers, but the results were unsatisfactory, as the tube sheets were deformed and cracked by the thrust of the tubes. Recently they have again been usd on about sixty four-cylinder compounds with narrow fire-boxes. In this case the tube sheets have been held together with stays and have stood well up to the present.

The tools used for fixing the tubes in the plates are the Dudgeon, the Caraman and the Boyer. They are sufficiently well known to make it unnecessary to give a description of them.

The holes have, as a rule, a taper of 1 in 40 or 1 in 50, and the drift of the tube expander has the same taper, so as to make a conical joint which helps to secure the tube to the plate. At the fire-box end the expanding is generally done in two operations, one before and one after the beading of the tube end.

The order in which the tubes are successively set in varies much on different railways, and this seems to show that it is of no importance. On the French Eastern, the tubes are set in and expanded in horizontal rows, alternately from right to left and from left to right. On the French Northern, the work is done in vertical rows, starting from the middle, and then doing a vertical row on the right and on the left alternately, but always going from the top to the bottom; experience would show that this method, which tends to drive the metal towards the edges, is the best for avoiding deformations of the tube sheet. On the Midi railway, the work is done in horizontal rows, starting from the bottom. On the Paris, Lyons and Mediterranean the work is done in vertical rows, starting from the extreme right or the extreme left row; but always starting at the top. On the Belgian State Railway no particular order is adopted.

Small importance need be attached to the order in which the tubes are set in, but the most rational procedure would seem to be that of the Northern Railway. If, however, it is advisable to drive the metal towards the side edges of the plate in order to avoid deformation, it would appear to be equally advisable to drive the metal towards the upper edge, and then the work should be done in vertical rows, starting from the center and always from the bottom to the top.

The railways which use steel tubes do not use ferrules, while those which have kept to brass tubes apply ferrules in order to protect the end of the tube against the fire and to improve the tightness. The thickness of the ferrules varies between 3-32 and 5-32 inch; their taper is the same, or is a little greater, than that of the holes in the tube plate. Ferrules have the great disadvantage that they materially reduce (at least by 10 to 12 percent in the case of smooth tubes) the clear cross-section available for the hot gases, and consequently the steam generation. On the other hand, they cannot be much depended on for increasing the tightness, for they easily work loose and get knocked out of place by the cleaning rods. As regards protecting the ends of the tubes, they are very efficient.

The steel tubes are nearly everywhere beaded over, at all events at the fire-box end, and often also at the smoke-box end. The bead at the end of the tube increases its strength, prolongs its life and protects the tube plate of the fire-box against the direct action of the hot gases at the joint. As leaks always start at the edge of the holes, it is very important to protect this spot by beading over the tube end. Finally, such beaded tubes are much less liable to become clogged; soot and other solid particles are much less likely to collect there; such matter would tend to obstruct the tubes more or less, and would materially interfere with the passage of the hot gases and consequently with the steam generation.

In the case of brass tubes, the practice of beading is less general. On the Belgian State Railway the brass tubes are beaded, while this is not done on the Italian railways and on most secondary railways. But the Italian railways have now for some time been trying ferrules with a flange, in order to protect the ends of the copper tubes against the flames, and this would show that such a protection is considered necessary.

Except on some of the Spanish railways the tubes are always arranged in vertical rows, as it is the general impression that this is best for the disengagement of the steam. As for the spacing, in the case of the 2¾-inch Serve tube the spacing is about 3½ inches, while for the smooth, 2-inch tubes it is about 2⅝ inches, or closely comparable with American practice.

In France nearly all of the locomotives constructed during the past ten years or so have had a working pressure of from 213 to 228 pounds per square inch. Special means to cope with these pressures, especially in keeping the tubes tight and maintaining the fire-box tube sheet are not taken. The Midi, in the case of its more recent locomotives, has connected the two tube sheets by stay-rods with the tubes. Other roads outside of France are also using high pressures.

It has everywhere been observed that boilers with a higher pressure suffer sooner and require more maintenance than the old boilers whose working pressure was not more than 170 pounds per square inch. It may be asked whether this result is wholly due to the increase of pressure, or whether it is due to any other cause, at least partly, and to an extent it cannot as yet be determined. For at the same time as the working pressure, the size of the fire-box has also been increased, and that in one dimension only, namely, longitudinally; for nearly all of the fire-boxes are in between the frame plates and are consequently all of the same width. It is argued, then, that it is evident that increasing the dimensions of the fire-box in one direction only has the effect of increasing the thrusts due to expansion. It consequently remains to be ascertained whether a large, wide fire-box, extending above the frames, and having a similar cubical content to the old fire-boxes, will not be stronger than a large, narrow box. If this were so, it would show that the increase of pressure were only a secondary cause.

If, however, we take the testimony of American engineers who have increased the pressures in their boilers, without, in many instances, making any change whatever in the dimensions, it appears to be very clearly settled that the increase of pressure has been responsible in itself for a great deal of the increase in the cost of boiler maintenance.

As for the influence of the spacing of the tubes on the damage done to the tube sheets, it appears to be the opinion of a number of officers that this has no influence whatever, as far as the production of cracks in the corners is concerned. But it is generally recognized that it is well to do the flanging with as large a radius as possible, and this has led to the placing of the outside rows of tubes and stays at some distance from the edge of the plates. It is also advisable, in order to avoid fractures of the interspaces between the tubes, to have the centers of the tubes as far apart as possible, or else to contract the ends of the tubes at the fire-box tube plate more than is usual; this also facilitates the circulation of the water and the disengagement of the steam, which is particularly brisk at the tube plate. Most of the French railways, in the case of Serve tube boilers, reduce by ¼ to 5-16 inch the diameter of twelve to fifteen tube holes in each upper corner of the tube plate.

Fire-box tube plates of copper are generally hammer-hardened by the cold hammering of the parts where the tubes enter; as a result, the tubes are held better, the tightening produced by the expanding being more effective.

The chief injuries in tube plates are cracks in the corners and fractures in the interspaces. In order to repair the former, copper angles are applied after removal of the part damaged; in the case of the latter, screwed copper rings are put in, expanded and beaded over; if the fracture extends from one hole to another, either an 8-shaped piece is applied, or else a stud is screwed into the damaged place before the copper rings are put in.

Several railways use the Ragno system. In this a thin copper sheet 3-32 to ⅛ inch thick is placed on the inside of the tube plate to which it is shaped, and is kept in place by ferrules placed in the tube holes and beaded over on both sides.

The length of the smoke-boxes of the newer French locomotives varies between 5 feet 10¼ inches and 6 feet 10⅝ inches. The smoke-boxes on some older locomotives have been made larger. The smoke-boxes of the Belgian State Railway have a maximum length of 6 feet 2 13-16 inches. Most of the foreign railways also have smoke-boxes of large size.

This increase of capacity has the advantage of making more uniform the vacuum produced by the exhaust, of giving the hot gases a large cross-section for their passage, while at the same time making it possible to reduce the size of mesh or the clear spaces between the wires of the metal screens used to arrest sparks, and of providing room for the cinders to settle without obstructing the lower tubes.

All the locomotives have steam domes, even the Pacific locomotives, which have the center line of their boilers 9 feet 6 inches above rail-level.

As a rule the insulating material simply consists of a layer of air; the boilers are surrounded everywhere, except at the lower part of the fire-box beyond the frame plates and below, by thin sheet supported on a light frame, 35 to 40 millimeters (1⅜ to 1 9/16 inches) from the surface of the boiler.

A certain number of railways have made trials of lagging. The French Eastern tried, in 1872, cork lagging and also slag-wool lagging; in 1887-1889, an asbestos lagging which was used on eighty-four locomotives; in 1890-1892, a silicate-cotton lagging which was used on sixteen locomotives. The conclusion drawn from these trials was as follows: "Taking into consideration the small saving which one can hope to effect and the disadvantages which such lagging presents as regards the maintenance of the boilers, it is advisable to give up fitting locomotives with such non-conducting coverings."

The French Northern has, as a trial, used asbestos lagging on two 4-4-0 compounds of the latest type, and on a tank locomotive, with six coupled wheels, of the Ceinture Railway. These laggings, when examined sixteen and twenty-four months afterwards, were found to be in good condition. But it was not possible to determine the saving owing to the difficulty of disentangling all the other factors which have a more material effect on the consumption. These solitary applications have not been extended. The use of lagging has disadvantages if the boilers are washed out with cold water. As the boiler cools more slowly, there may not be time available to wait till it is quite cold. Now, as we have seen above, this is one of the causes of leaky tubes.

The Midi is at present making trials with a lagging consisting of magnesium carbonate. The saving in fuel resulting from the use of such lagging is stated to be 2 to 3 percent.

The Paris-Lyons-Mediterranean is trying various kinds of lagging, but states that it has as yet not determined their value.

The Italian State Railway is also trying various laggings: magnesia, white asbestos, blue asbestos from the Cape.

The Belgian State Railway uses, as a general rule, a non-conducting covering consisting of asbestos matting covered over with thin sheet iron. The back of the fire-box is protected by boards with a coat of silicate paint, also covered by thin sheet iron. On some tank locomotives, the inside of the roof of the cab is also lined with boards.

Comparative trials made with locomotives with asbestos lagging and locomotives with simple sheet iron lagging have not made it possible to determine the saving in fuel. It has, on the other hand, been observed that locomotives with lagging take, on the average, 3 hours longer to cool than those which have no lagging.

The conclusions that are drawn from the report, as far as France, Belgium, Spain, Italy and Portugal are concerned, are that the tendency is still towards the retention of copper fire-boxes; the use of stays rather than crown bars for the fire-boxes; the introduction of the rocking grate; the adoption of steel tubes, except where the water is bad; a fall in favor of the Serve ribbed tubes and the application of means to reduce the leakage of the tubes in the tube sheet without any definite results having as yet been obtained.—*Railroad Age Gazette.*

THE MODERN LOCOMOTIVE BOILER.*

BY JOHN W. HOBSON.

Although the modern boiler is the same in principle as the boiler of the world-famous "Rocket," yet what an increase in size and an improvement in design and detail! The old "Rocket" boiler had a heating surface of 138 square feet, whereas 2,000 square feet is now quite common in this country, to say nothing of a boiler being constructed in America which is to have 7,840 square feet. For the space occupied, the locomotive boiler is one of the most powerful in existence, due to the vibration to which it is subjected when running assisting the escape of the bubbles of steam from the fire-box and tubes. This allows the drafts being forced to an extent out of all comparison with stationary locomotive boilers.

* Read before the Graduate Section of the North-East Coast Institution of Engineers and Shipbuilders.

On the locomotive it is possible to burn 125 pounds of coal per square foot of grate area per hour, whereas 27 pounds appears to be the limit when working stationary.

The locomotive boiler is not the most economical steam producer by any means, but it is a very quick one, on account of the small water capacity and the extent to which it may be forced. The induced draft is sometimes as high as 8 inches water-gage in the smoke-box, though 5 inches is the most economical, but it may be readily forced, and is thus well adapted for its purpose. Its efficiency is about 65 percent.

The rate of combustion of coal varies from 40 to 120 pounds per square foot of grate per hour, according to its quality and the degree of forcing, the temperature in the smoke-box being from about 500 degrees to 700 degrees, and in the fire-box from about 2,000 degrees to 2,400 degrees Fahrenheit. The rate of evaporation is rather peculiar, inasmuch that large and small boilers appear to deliver about the same quantity of steam per unit area of heating surface. When practically new they generally deliver from 12 to 13 pounds of steam per square foot of heating surface per hour, though they have been known to deliver as much as 15 to 16 pounds per square foot, but it was at a serious expense, viz., at the rate of 6 pounds of water evaporated per pound of coal consumed.

Under conditions of maximum economy locomotive boilers should evaporate from 10 to 12 pounds of water per pound of dry coal. Under ordinary working conditions, however, 1 pound of Welsh coal evaporates about 9 pounds of water, and 1 pound of Newcastle, Yorkshire or Scotch about 8 pounds. The quality of steam delivered varies with different boilers, and also with changes in power, but it generally possesses 98 percent of dryness.

The average life of locomotive boilers is generally stated to be from 8 to 10 years, although I know a local company possessing many locomotives using bad feed water, and their boilers always last 15 years. Of course, the working pressure is only 150 pounds per square inch, and the plates are of Lowmoor iron.

The boiler question with high working pressures has become one of the most formidable that locomotive engineers of the present day have to deal with. They have the greatest difficulty in keeping tubes and stays tight, and the wear and tear is enormous when working with pressures of 200 pounds per square inch and upwards. The initial cost of what is considered a well-designed modern boiler is a serious item and the cost of maintenance cannot be overlooked.

DESIGN.

The chief features to be observed for good design are briefly as follows: To make the boiler and fire-box of such a shape as to suit the design of the engine, and at the same time to distribute the heating surface of fire-box and tubes in such a manner as to obtain the most complete combustion of the fuel. The products of combustion should not be diluted by excess of air, but at the same time the draft is not to be checked, as it is necessary to keep the temperature in the fire-box as high and even as possible, or stay and tube troubles will result. It should also be designed so that it can be constructed as cheaply as possible, with a minimum of mechanical difficulty, and should be made accessible in order to facilitate periodical cleanings, and to provide for repairs and renewals being performed as cheaply and expeditiously as possible. It should be constructed of such materials that it shall be durable, every part being as nearly as possible uniform in strength, allowance being made to balance the loss of strength in parts subject to greater wear and tear, so that it is not necessary to scrap it simply for local defects.

The evaporative power of a boiler depends upon the capability of its heating surface to transfer heat from the solid fuel, flame in the fire-box and the gases in the tubes, to the water on the outside of the same. The radiation from the solid fuel and brick arch is more effective than contact with the flame, while compared to these the gases in the tubes impart very little heat per unit area, being relatively much cooler. The superiority of fire-box heating surface over tube heating surface is, of course, due to the radiant heat given off and the flame being at such a high temperature in the fire-box, while the gases in the tubes, although at a high temperature

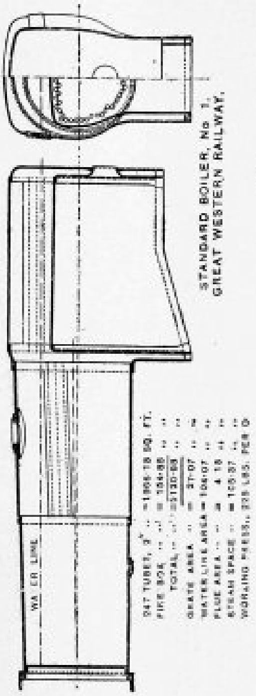


FIG. 3.

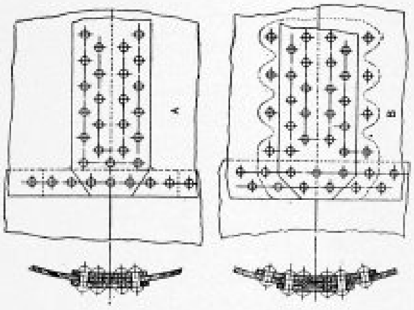


FIG. 5.

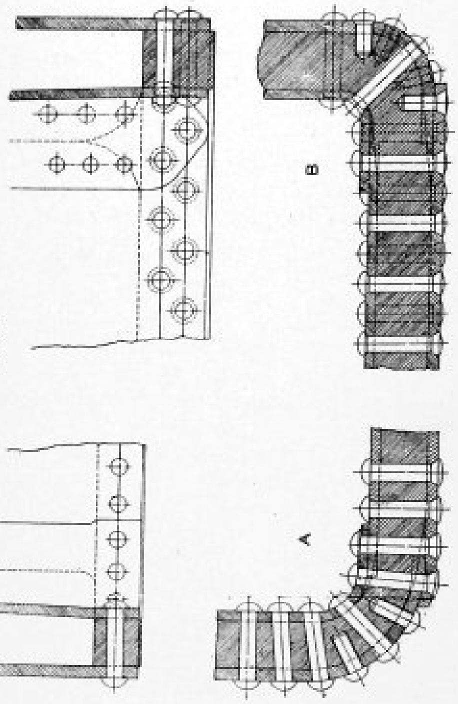


FIG. 6.

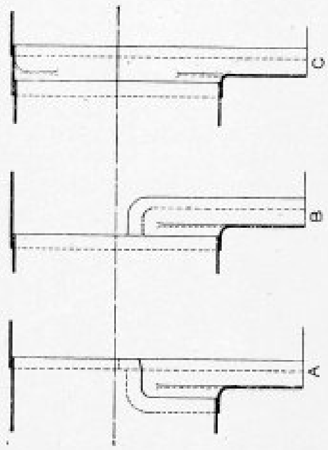


FIG. 4.

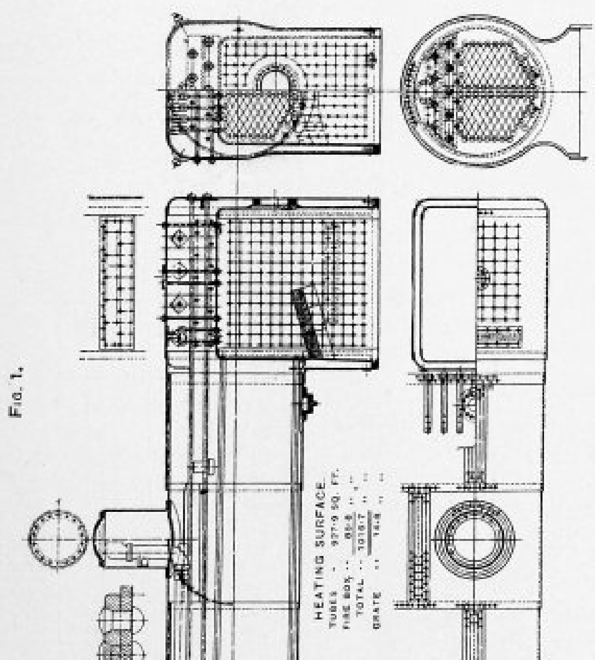


FIG. 1.

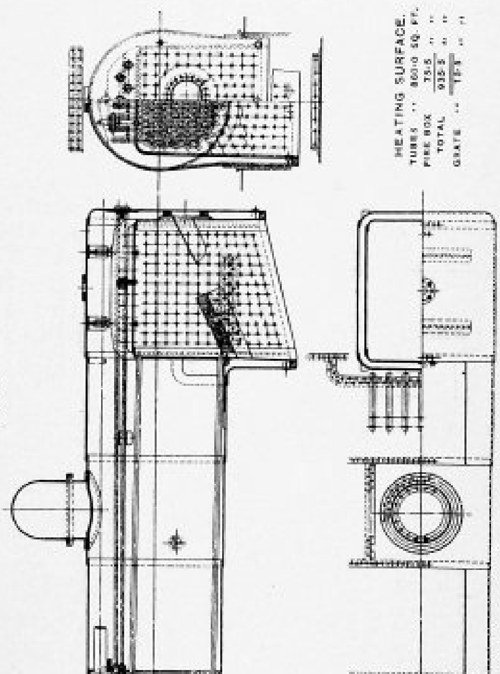


FIG. 2.

on leaving the fire-box, cool down rapidly. Again, the upper part only of a tube is effective, as the tendency of gases is to creep along the top; besides, the bottom part has generally a coating of soot. Also, steam bubbles can escape more readily from the fire-box than from the tubes, and the fire-box can be kept freer from scale than the tubes, although copper and brass tubes keep themselves fairly free from scale by reason of their rapid expansion and contraction throwing it off. The ebullition around the upper part of the fire-box is very violent, as may be expected.

Now, in estimating the heating surface it is usual to take the surface of the fire-box in contact with heat, and the surface of the tubes in contact with the water, and then consider the evaporative power of the boiler as being proportional to the total number of square feet so found.

From the foregoing remarks relative to the superiority of fire-box heating surface, this cannot be considered fair. A good way to compare the evaporative power of two boilers is to use a formula such as that proposed by Mr. Vaughan in 1904. Mr. Vaughan bases this formula on experiments conducted by Petiet in 1865, and suggests that for purposes of comparison the equivalent heating surface, that is, a heating surface which is proportional to the evaporative power of the boiler is given by this formula. This formula shows clearly that increasing the heating surface by merely lengthening the tubes does not increase the evaporative power of the boiler in the same ratio. For instance, the equivalent fire-box heating surface of the boiler shown in Fig. 1 is 223.4 square feet; now, by increasing the total heating surface 10 percent by lengthening the tubes, the equivalent fire-box heating surface becomes 232.4 square feet, which merely shows an increase in the evaporative power of 4.03 percent, according to this formula.

With respect to the necessary heating surface or grate area for a certain engine, I may say there is no fixed ratio of piston area or cylinder capacity to heating surface or grate area, as is clearly shown by the table given below.

A boiler should always be designed for the work it has to do, but, as a rule, it is only main line designers, men who know every mile of the line and every gradient, who are able to do this, as contractors are seldom supplied with full data, such as gradient and curve charts. When it is possible to obtain the average indicated horsepower the engine is likely to develop, the total heating surface in square feet should be made about three and one-quarter times this. I find from observation that this ratio gives very good results. The ratio of total heating surface to grate is usually in this country about 70 to 1, and the total heating surface to fire-box heating surface 12 to 1.

For main line engines the ratio of total heating surface to piston area is nowadays about 850 to 1. I may say 750 to 1 was considered sufficient a few years ago. Of course this does not apply to contractors or shunting engines, etc.

There is in this country great difficulty in obtaining a large enough grate area for the large boilers now required. The fire-boxes are either of the wide type known as the Wooten type or they are long and narrow. The Wooten box is very much used in America and on the Continent, but the narrow is almost universal in this country. A modified form of the Wooten types is at present having a trial on the Great Northern Railway. The wide type is used generally when inferior fuel or fair quality small coal is to be burnt. This, of course, is an American or Continental reason, but the British reason is to obtain exceptional boiler power when using good coal. The wide type is certainly preferable when poor coal is to be used, but greater waste goes on when the engine is standing. It also requires greater skill in firing, as if the grate becomes uncovered, tube leaking is sure to result.

The bottom of a fire-box may be horizontal or sloping, or partly horizontal and partly sloping. With the sloping type the fuel shakes down and helps to prevent clinker forming, but care should be taken not to have the incline too severe or the fire shakes down too rapidly and uncovers the back of the grate. An incline of 1 in 10 is very satisfactory, but the wheel arrangement sometimes makes this impossible. With the sloping bottom sediment is more easily removed. The total air space between the fire-bars varies from about 1/4 to 1/3 the grate area.

The length of the boiler barrel is usually decided by the type of engine, but at the same time the length ought not to be excessive, as the floating tendency of the tubes causes a movement tending to loosen them in the tube plates, and also

VAUGHAN'S FORMULA FOR THE EQUIVALENT FIREBOX HEATING SURFACE $h = \frac{2}{3}\frac{H}{\sqrt{L}} + \frac{F}{2}$

Where h is the equivalent firebox heating surface in square feet,
H = tube heating surface in square feet; L = length of tubes in feet; F = firebox heating surface in square feet.

Railway.	Type.	Tender or Tank.	Cylinder.	Driving Wheels.	Working Press.	Tractive Force.	Adhesive Weight.	Total Weight.	Heating Surface in Square Feet. Tubes.	Fire-box.	Total.	Grate.	Area of Piston.	Volume of Cylinder.	T.H.S. / Piston Area.	T.H.S. / Vol. of Cyl.	T.F. × Drivers / H.S.	H.S. / Grate.	F.H.S. / Grate.	T.H.S. / F.H.S.	Adhesive Weight / H.S.	Total Weight / H.S.
			Inches.	Ft. In.	Lbs.	Lbs.	Tons.	Tons.				Sq Ft	Sq Ft	Cu Ft								
Great Northern	4-2-2	Tender	18 ×26	7 7½	170	12,500	17.5	47.5	1,144	126	1,270	23.2	1.767	3.83	720	332	900	54.8	5.43	10.1	30.8	84
Midland	4-2-2	"	19½×26	7 9	170	14,450	18.5	47.1125	1,105	128	1,233	21.3	2.07	4.49	596	274	1,009	57.8	6	9.63	33.6	85.5
Great Western	4-2-2	"	19 ×24	7 8	160	12,050	18	49	1,434	127	1,561	20.8	1.969	3.94	794	396	710	75	6.1	12.3	25.8	70.3
Great Central	4-2-2	"	19½×26	7 9	200	17,000	18.35	47.25	1,062	132	1,194	24.8	2.07	4.49	576	265	1,325	48.1	5.32	9.05	34.5	88.8
North Eastern	4-4-0	"	19 ×26	6 10	200	18,300	35.25	51.7	1,383	144	1,527	20	1.969	4.27	776	358	983	76.3	7.2	10.6	51.6	75.6
Caledonian	4-4-0	"	19 ×26	6 6	180	17,350	35.75	54.375	1,470	145	1,615	21	1.969	4.27	820	378	838	77	6.91	11.1	49.6	75.4
London & N. Western	4-4-0	"	19 ×26	6 9	175	16,200	38	59.75	1,848	161	2,009	22.4	1.969	4.27	1,015	473	653	88.5	7.2	12.5	42.3	66.6
Highland	4-4-0	"	18¼×26	6 0	175	16,900	31.2	46	1,060	115	1,175	20.3	1.815	3.93	648	299	1,035	58	5.67	10.2	59.5	87.6
Indian North Western	4-4-0	"	18½×26	6 2	180	17,350	30.96	49.8	1,229.5	120	1,349.5	25.3	1.87	4.05	722	334	950	53.4	4.75	11.25	51.4	82.6
Great Northern	4-4-2	"	18¾×24	6 7½	175	14,850	31	58	1,302	140	1,442	26.7	1.915	3.83	753	376	820	54	5.24	10.3	48.2	90.2
Lanc. & Yorkshire	4-4-2	"	19 ×26	7 3	175	15,100	35	58.75	1,877	176	2,053	26.1	1.969	4.27	1,040	480	640	78.5	6.75	11.63	38.2	64.2
North Eastern	4-4-2	"	20 ×28	6 10	200	21,900	39	72	2,276	180	2,456	27	2.182	5.08	1,125	484	730	91	6.67	13.6	35.6	65.8
Great Central	4-4-2	"	19½×26	6 9	180	17,600	37	68.5	1,778	133	1,911	26	2.07	4.49	924	425	745	73.6	5.12	14.4	43.4	80.3
North British	4-4-2	"	20 ×28	6 9	200	22,150	40	74.4	2,071	185	2,256	28.5	2.182	5.08	1,035	445	795	79	6.5	12.17	39.8	72.5
Great Western	4-6-0	"	18 ×30	6 8½	200	19 200	51.9	68.3	2,252	158	2,400	27.2	1.767	4.42	1,360	544	645	88.2	5.81	15.2	48.5	63.8
North Eastern	4-6-0	"	20 ×26	6 8½	200	20,750	51.95	67.1	1,639	130	1,709	23	2.182	4.73	810	374	942	77	5.65	13.6	65.7	84.8
Caledonian	4-6-0	"	19 ×26	5 0	175	21,900	42.85	57.4	1,800	105	1,905	20.6	1.969	4.27	967	446	690	92.5	5.1	18.15	50.3	67.5
Great Western	4-6-0	"	20 ×24	4 6	165	23,450	47.2	59.5	2,270	115	2,385	35	2.182	4.364	1,093	547	533	68	3.3	20.7	44.3	55.9
Great Northern	0-8-0	"	19¾×26	4 8	175	25,350	54.6125	54.6125	1,302	137	1,439	24.5	2.13	4.62	676	312	986	58.8	5.6	10.5	85	85
Great Central	0-8-0	"	19 ×26	4 7	180	24,600	61.25	61.25	1,625	140	1,765	23.6	1.969	4.27	896	413	766	75	5.93	12.6	77.8	77.8
North Eastern	0-8-0	"	20 ×26	4 7¼	200	30,100	54	54	1,574	125	1,699	21.5	2.182	4.73	780	359	980	79	5.82	13.6	71.1	71.1
Indian Government	0-6-0	"	18½×26	5 1½	180	20,800	48	48	1,229.5	128	1,357.5	25.3	1.87	4.05	726	336	943	53.7	5.06	10.6	79.1	79.1
L. B. & S. C.	0-6-0	"	17½×26	5 0	170	18,050	49.5	49.5	1,183.4	101.3	1,284.7	18.64	1.67	3.62	770	355	843	69	5.44	12.7	86.3	86.3
North Staffordshire	0-6-2	Side tank	18½×26	5 0	175	20,800	...	...	1,057.3	108.3	1,165.6	17.8	1.87	4.05	624	288	1,070	65.6	6.1	10.76	...	...
Cork & Macroon	0-6-2	"	16 ×24	5 1	160	12,900	36	45	959	87	1,046	16	1.4	2.8	748	374	752	65.4	5.44	12	77	96.4
L. B. & S. C.	4-4-2	"	17½×26	5 6	170	16,400	36.6	68.3	1,183.4	101.3	1,284.7	18.64	1.67	3.62	770	355	844	69	5.44	12.7	63.8	119
L. & N. W.	4-4-2	"	19 ×26	6 3	175	17,500	39.5	74.75	1,777.5	161.5	1,939	22	1.969	4.27	985	454	677	88	7.34	12	45.6	86.3
WarOffice (by Avonside)	0-6-0	Saddle tank	14 ×20	3 3	160	12,850	29.75	29.75	446	52	498	8.25	1.07	1.787	467	279	1,006	60.5	6.3	9.6	133.8	133.8
Pontop & Jarrow	0-6-0	"	17 ×26	4 6	150	16,700	43.5	43.5	856.24	75.5	931.74	15.15	1.576	3.42	591	272	968	61.5	4.98	12.3	104.5	104.8

the ratio of the length to diameter of tubes has an important bearing on the steaming capacity of a boiler. The most economical ratio is considered to be about 80 to 1.

The feed water should be injected into the barrel well up to the front, and about on a level with the boiler center. The water level is about 5 inches above the fire-box crown.

BOILER BARREL AND FIRE-BOX CASING.

The most common form of boiler barrel in this country is that known as the telescopic, with the smallest ring at the smoke-box end, Fig. 1. Sometimes, however, the circumferential joints are butt-jointed with outside straps only, which arrangement allows much more space around the tubes at the smoke-box end. With the telescopic form the barrel is much easier cleaned out, as the sediment flows towards the fire-box, where it is easily removed.

Another form of barrel which has come very much into favor on the Great Western Railway, and, in fact, has been adopted as their standard, is the coned barrel, Fig. 3. In America this is the favorite form, and is there known as the wagon top boiler. With this type a good steam space is obtained in the most favorable position, and it also gives much more water around the tubes at their hottest part.

The most common form of fire-box in this country as yet is that known as the round top box finished parallel with the barrel, Fig. 2, but the flat top box, called the Belpaire, Fig. 1, is fast superseding it. The chief objection to the Belpaire box was the expensive flanged plates, but since the introduction of hydraulic flanging machinery this objection has been overcome. The advantages of the Belpaire box are many, and are becoming recognized to such an extent that this type promises to become well nigh universal in the very near future. The steam space is increased by about 20 percent over that of the round top box. With the round top box, three plates come together at the sides of the throat plate, making a joint which very often gives trouble. Fig. 4, sketches A and B, show the joints referred to. Sketch C shows a Belpaire throat plate joint. From these sketches it will be noticed that more rivets are required for the Belpaire throat plate joint, but this adds only trifling expense.

As girder stays for the fire-box crown are objectional and direct stays do not always give satisfaction when used in a round top box, it will be seen that another difficulty is overcome by using the flat top box.

Although this fire-box has just recently been adopted to any extent on British main lines, yet private builders have recommended its use and supplied them for service abroad for many years. Messrs. R. & W. Hawthorn constructed in 1867 locomotives for the Stockton and Darlington Railway which had this form of fire-box, and in 1872 supplied engines to the Sardinian Railways also fitted with it. Since then this company has constructed a very considerable number of boilers having the Belpaire fire-box. I may say the Belpaire box is the type recommended by the Indian Standards Committee.

The boiler barrel is, as a rule, made up of three plates, and the fire-box wrapper is generally a single plate. The barrel is usually connected to the smoke-box tube plate by means of a weldless steel angle ring, as shown in Fig. 1. There is, however, a tendency of leakage taking place between the barrel plate and the angle, the result being that the barrel plate becomes corroded before being noticed, as it is hidden with the clothing. This objection may be overcome by having the drumhead tube plate as shown in Fig. 2. This is the tube plate used principally in America. It is customary in this country, without good reason, to make this plate about half as thick again as the barrel plates. In large boilers in America it is generally thinner than the barrel plates.

Barrel plates of steel are usually stressed to about 5½ tons per square inch in new boilers, which allows a good factor of safety. This is a good plan, as corrosion, usually rapid, is amply allowed for.

Steel plates made by the Siemens-Martin process have now practically supplanted iron, which was formerly used in boiler construction. In the United States and Canada steel is exclusively used, and by the most important railway companies on the Continent, though Russian engineers still persevere in the use of iron, which they say is better able to stand the excessive cold in winter; but the cold is quite as intense in Canada, where steel is used with success.

Steel is superior to iron as a material of construction, but iron lasts longer with certain kinds of feed water. Again, iron plates cost double the price of steel and can be only obtained in small sizes. Steel is more homogeneous than iron, equally strong lengthwise and crosswise, and is seldom laminated. Steel plates possess a ductility superior to iron, though they do not weld quite so satisfactorily.

Great care should be exercised in choosing steel plates and afterwards treating them properly, special attention being paid to the special qualities of steel. The plates should be of a very mild nature, possessing chiefly great ductility. Tensile strength may be only a secondary consideration, except when it is necessary to construct a boiler as light as possible. Only good quality plates will stand flanging, punching and welding with impunity. The barrel and fire-box wrapper plates are bent cold in rolls, but the tube plate, throat and back plates should be flanged by hydraulic power at a heat above cherry red. Hydraulic flanging is preferable to hand, as if done by hand successive heats are required, all flanging being stopped when the plates have cooled to a blue heat. This is very important, as, if not observed, cracks may appear after cooling. After flanging, the plates should be annealed and left to cool slowly.

The following are tests taken from the British standard tests, and I would draw your attention to the bending tests, which I consider most important, seeing that locomotive boiler plates require to undergo so much bending and flanging:

All plates to be made from acid open-hearth steel from selected material, and must not show on analysis more than .05 percent of sulphur or phosphorus, and must be free from cracks, surface flaws, laminations and all other defects. No plate to be under the specified thickness at any part nor more than 5 percent over the calculated weight. The tensile strength is to be from 26 to 32 tons, with an elongation of not less than 22 percent on 8 inches. Test pieces to be sheared crosswise from plates and bent; others similar to be heated to a blood red, then quenched in water at a temperature not exceeding 80 degrees Fahrenheit. The color to be judged indoors in the shade. For both cold and temper bends the pieces must stand, without fracture, being doubled over until the internal radius of bend is not greater than the thickness of the test piece and the sides are parallel. These tests may be made either by pressure or blows.

(*To be concluded.*)

Real Cause of Boiler Explosions.

William Sellers, the famous machine tool maker, was not noted as a public speaker, but when he ventured to say anything at engineering meetings his words were remembered. At one time years ago Philadelphia was much excited on the subject of boiler explosions, several accidents to boilers having wakened the natives. William Sellers attended one of these meetings, and was asked to explain his theory of the cause of boiler explosions. The reply came promptly: "Because the pressure inside is greater than the strength outside."—*Railway and Locomotive Engineering.*

The Boiler Maker

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CIRCULATION STATEMENT.

Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

Notice.

The next convention of the International Master Boiler Makers' Association will be held at Niagara Falls, N. Y., instead of Cincinnati, Ohio, as was planned at the last convention. The time of the convention will be announced later.

Oxy-Acetylene Welding.

Boiler makers have watched the development of oxy-acetylene welding with great interest, since it has given promise of being practically the only method of welding which can be applied to boiler work. The cost of welding by this process is comparatively low, the apparatus is easily portable, and large, heavy pieces can be conveniently welded in place without much previous preparation or machine work. It is particularly adaptable to boiler repair work. The only thing which needs to be demonstrated is that reliable work can be done giving welds of known efficiency. It is natural that any weld should be looked upon with suspicion, because there is no means of determining exactly what strength it has until it has been tested. Over-zealous salesmen and demonstrators have undoubtedly been ready to claim too much for the oxy-acetylene process of welding, and, finding a ready and receptive public, have, perhaps, pushed these claims beyond the bounds of good judgment. The letter which we publish on the opposite page would at least seem to indicate this. In the demonstration described by our correspondent the process was a failure in every respect. Apparently not one of the welds held. Believing that comments on this demonstration from various manufacturers of oxy-acetylene welding apparatus would be of interest to our readers, we sent advance proofs of Mr. Lester's communication to the manufacturers and others interested, hoping to receive some comments. The replies indicate that the unsuccessful demonstration in this case must have been due largely to the lack of skill of the operator. Obviously, the handling of oxy-acetylene welding apparatus cannot be left to a common day laborer as much other work in a boiler shop can be. It is a kind of work which requires intelligent and skillful workmen. In the account of the large repair job on a marine boiler which was carried out by this process, a description of which is published on page 278, it should be noted that the work was under the immediate supervision of one of the best-known experts on oxy-acetylene welding in England, and up to the present time, at least, the work has given satisfaction. Undoubtedly enough good work has been done by this process to offset the unsuccessful attempts, and this in time will undoubtedly gain for oxy-acetylene welding the consideration and prestige which it deserves.

Marine Boilers Must be Fitted with Two Independent Feed Pipes.

The Department of Commerce and Labor has issued an order requiring all licensed steamboats to be equipped by Oct. 31 with two independent feed pipes for the boilers. A similar regulation was issued some time ago by the executive board of the Steamboat Inspection Service, requiring two independent feed pipes, on the ground that boilers equipped with only one were in danger of exploding, and thus endangering the lives of passengers and crew, in the event that the one feed pipe as now used should get out of order and the water level be lowered to a dangerous point before the fires could be drawn. This regulation was protested by the representatives of a good many steamboats plying in waters around New York and Philadelphia and other large ports which are equipped with only a single feed pipe. A hearing of these protests before the assistant secretary of the Department of Commerce and Labor and the executive board of the Steamboat Inspection Service resulted in an order from the Department of Commerce and Labor confirming the action of the executive board of the Steamboat Inspection Service, and stipulating that the licenses of all steamboats not equipped with two independent feed pipes on Oct. 31 would be canceled. The protest of the steamboat men was on the grounds of the expense involved in making the necessary changes, a common enough complaint on the part of those who habitually try to block the introduction of necessary precautions for the safety of the traveling public.

Although the number of boiler explosions in England during the year ending June 30, 1909, was slightly above the average for the previous twenty-five years, yet the resulting loss of life and number of injuries were below the average. There were 73 explosions (47 on land and 26 on board ship), twenty-three persons were killed and fifty injured. Compared with the holocaust that occurs each year in America from the same cause, these figures are refreshing.

COMMUNICATIONS.

Oxy-Acetylene Welding.

EDITOR THE BOILER MAKER:

I have recently had an opportunity to give oxy-acetylene welding a practical test in boiler work, and the results may be of interest to your readers.

Previous to the test, I had received some literature from several concerns illuminating their several processes; I had also attended a convention, and saw samples which the devotee (I believe "devotee" is the proper word, for he was as enthusiastic with his process as a little girl with a new doll) claimed was welded with the oxy-acetylene process. The samples looked very nice on the surface, but, as none of them had been subjected to a tensile test, I could not tell how they looked beneath the surface, or what strain they would stand. However, the exhibitor claimed to have subjected welded pieces of boiler plate to a tensile test, and that the weld stood the test, the plate pulling apart in the solid plate.

With the literature mentioned and the foregoing evidence I was, of course, greatly impressed, and returned home with visions of revolutionizing boiler making and repairing in the shops of the railroad with which I am connected.

It developed, however, that I was not the only enthusiast, or rather, not the only one along our road, impressed, for at the time I was about to communicate with my superior in the mechanical department in reference to having some concern demonstrate what they could do, I received a communication from my mechanical superintendent stating that the ——— Company would have a representative on a certain date at one of our large shops to make a demonstration.

In this letter I was requested to prepare for the demonstration, and have on hand some engines with cracked side sheets, flue sheets with broken bridges and other cracks and broken iron castings to weld.

The day the demonstration was due I had on hand an engine with a flue sheet cracked from a bottom flue hole down to a stay-bolt that held one of the belly braces in place a distance of about 4 inches; a new flue sheet, of the kind used in the Pacific type engines, that had been cracked from the edge to the root of the flange while off-setting the sheet under the rolls; a piece of broken iron cab casting; four pieces of fire-box steel to weld up for testing tensile strength on the testing apparatus; 20 feet of ⅝-inch plate to rip and a piece of chrome safe steel to rip.

The representative put in an appearance on the date agreed upon, but the oxygen and acetylene tanks did not materialize until the next day. A portion of the time while we were waiting for the tanks I spent with the demonstrator, getting all the points possible and showing him the stuff I had prepared for him. He was very sanguine, and to hear him tell it he could weld up anything from a crack in a fire-box to a flaw in the blade of a safety razor. Steel, cast iron, copper, brass, gunmetal and several other metals I do not recall could all be welded with equal facility. Notwithstanding all this I still maintained implicit faith in him and his process.

During this time, under the direction of the demonstrator, I had all the cracks V-ed out to facilitate the fusing of the metals all through the plate, in order to make a good weld.

Finally the tanks arrived, and in the presence of the mechanical engineer, chemist, general foreman boiler maker, master mechanic, engineer of tests, foreman boiler maker, and several other officials interested, the demonstrator began on the old, cracked flue sheet.

The blaze from the burner throwing a flame about ⅛ inch in diameter and about ¾ inch long, and at a temperature claimed to be in excess of 6,000 degrees F., was thrown on the plate at the section to be welded. The operator held the burner with one hand, and with the other hand used a strip of fire-box plate about 5/16 inch square and about 2 feet long, in a manner that a tinner uses a sheet of solder. When the two metals were brought to the desired temperature they were puddled together. This operation was completed in about twenty minutes, and at a cost of about 50 cents for labor and fuel.

The other flue sheet, the test pieces and the cast iron were welded up in the same manner and at slight cost. When completed they looked very well on the surface. Finally the chrome steel, a piece ⅝ inch thick by 7 inches long, was ripped in about thirty seconds and 20 feet of boiler plate ⅝ inch thick was ripped in twenty minutes, at a cost of $1.32 for labor and fuel.

Every one who witnessed the demonstration was enthusiastic, and all sorts of wondrous things were predicted. The operation of ripping plate was, in itself, a practical demonstration that the process would be a great saver of time and money in cutting channel bars, boiler plate, shafts in position and other things innumerable.

Our mechanical superintendent was soon to attend the master mechanic's convention, and desired a report to take with him. Immediately after the test I wrote him a glowing account of the possibilities for the process in a railroad shop.

The next day the test pieces were pulled for a tensile test (I have neglected to say that the demonstrator guaranteed 90 percent efficiency for the weld). The fire-box steel used for the test pieces had a tensile strength of about 55,000 pounds. Under the test one broke with no elongation at about 11,500 pounds, and the other one with no elongation at about 21,000 pounds. In this interval the flues had been applied to the boiler in which we welded up the crack in the old sheet. I witnessed the test. The boiler was required to be tested with cold water at 225 pounds (180 pounds working pressure and 25 percent excess cold water). The weld gave out at 150 pounds. The cab casting was allowed to drop about 8 inches onto the floor and broke. The new flue sheet welded in the flange pulled apart within five hours after welding, simply by the contraction of the sheet in cooling. It may be superfluous to add that I immediately furnished another report to the mechanical superintendent, in which the ardor I displayed in the first report was conspicuous by its absence.

The foregoing statements cover my entire experience with the process of autogenous welding. Despite the very discouraging results we obtained I am sure that the process is a success, and hope that this article will bring out papers from practical men who have used the process—to their entire satisfaction—and can tell me what was wrong. I will say, further, that the demonstrator did not preheat the plate surrounding the part to be welded before starting the weld.

Oxygen and acetylene, when properly mixed, form a gas which is highly inflammable, and when burned at a high rate by the use of oxygen at a high pressure, the gas can be made to increase the intensity of heat up to 6,000 or more degrees F. The chemical equation which shows the action of oxygen when combined with acetylene is as follows:

$$C_2 H_2 + 2.5\, O_2 = 2\, CO_2 + H_2 O.$$

From the above it can be seen that twenty volumes of oxygen, plus one volume of acetylene, are required to form on ignition two volumes of carbon dioxide plus one volume of water. As steam dissociates at temperatures above 2,000 degrees F. into hydrogen and oxygen, this free oxygen is available to combine with the acetylene, and thus reduce the consumption of this gas.

At the high temperature which this combination of gases affords, welding of almost every description should be made possible. However, on account of the concentrated heat which is afforded by the apparatus, and the gases which are given off, due to the incomplete combustion of the fuel, forming *CO*, there is danger of forming an imperfect weld. I believe the danger lies in the local stresses which are set up, due to uneven and rapid cooling of the material directly after the source of heat is removed.

These stresses and conditions cause the metal to become crystaline in the vicinity of the weld, and if care be taken to relieve these strains by annealing, the efficiency of the weld ought to approximate 90 percent, but if the weld is not annealed there will be danger of fracture of the metal at the slightest shock.

It appears to me that in case where annealing is not possible, as much of the surface adjacent to the fracture, or all, if possible, should be preheated and kept heated during the welding process, after which the temperature should be radiated from the surface slowly and evenly, so that no local strains can be formed.

The gases which arise, due to incomplete combustion of the fuel at the end of the blow pipe, combine with the metal and form ferro-carbonate and iron oxide, which compositions lower the efficiency of the weld considerably.

This difficulty can, no doubt, be obviated by the operator becoming familiar with the appearance of the flame, which gives off no incompletely-burned carbon, in which event there will be no detrimental chemical actions taking place during the process.

The production of acetylene is affected by the following equations:

Lime.	Coke.	Calc. Carbide.
CaO	$3C$	$CaC2\ CO$

$$CaC2 + 2H_2O = C_2H_2 + CA\ (OH)_2.$$

The yield of acetylene at atmospheric pressure from a pound of commercially pure lump CaC_2 may be taken as from 4 to 4.5 cubic feet instead of 5.5 cubic feet, as would be the case were the CaC_2 pure.

A simple method of producing free oxygen is to take eight parts of potassium chlorate and one part of manganese dioxide, to form after application of heat eight parts of potassium chloride, one of manganese dioxide and eight parts of oxygen.

By this process oxygen is given off and washed in a scrubber and then drawn out and compressed to any desired pressures.

C. E. Lester,
General Foreman Boiler Maker,
Erie Railroad Company, Meadville, Pa.

Editor The Boiler Maker:

We greatly appreciate the opportunity to comment on Mr. Lester's criticism of oxy-acetylene welding as applied to boiler work. As prominent manufacturers of oxy-acetylene apparatus, we are gratified that the demonstration, which was such a failure, was witnessed by a person of such intelligence, and that his faith in the process could not be destroyed by the very bad results. Had the operator been equally intelligent, he would not have been so reckless in his predictions. He simply melted the metal, but did not weld it, either because his apparatus was imperfect or because he did not know how, or possibly he failed for both reasons.

Successful welding by the oxy-acetylene process is a new art, and it cannot be acquired in a few days any more than other arts, and of all the operations performed by the process, boiler welding is the most difficult.

Our company has established probably what is the only demonstrating plant in the world devoted exclusively to the development of the oxy-acetylene welding and cutting process, and we have welded everything from typewriter bars to cracked cast iron melting pots, from 3 to 4 inches in thickness, and weighing from 5 to 6 tons. We have spent many hundreds of dollars in boiler welding experiments, and only recently our Mr. Bournonville returned from his fourth trip to Europe in studying the process; this last trip being almost exclusively to gain information about boiler welding. While we have succeeded in making many successful welds, it is only very recently that we have felt that we can succeed in most cases. At this writing we have just arranged with the master mechanic of a large railway shop for extensive demonstrations in this line, and we feel confident that we shall be generally successful.

Three very important things are necessary to succeed in boiler welding, viz.:

Apparatus that will supply pure gases, under uniform pressure, in a manner that will produce a neutral flame.

An experienced, skillful operator, familiar with the conditions of steel under high temperature.

Knowledge and resourcefulness in overcoming contraction and expansion.

It is impossible to treat all these requisites in the present article, but the fact that the apparatus of our company is in successful operation in more than 100 of the leading industrial concerns in this country, including five in the United States navy, ought to be satisfactory evidence that we can fulfill the first requirement. An excess of acetylene will carburet and destroy the strength of the weld, and too much oxygen will injure the same by oxidation, and without proper control the neutral flame cannot be maintained. Impure gas will injure a weld.

So far as operators are concerned, we believe we have some of the most experienced in this country. Not only must the operator be able to maintain a neutral flame, but the flame must be of a size adapted to the metal to be welded.

In boiler welding, expansion and contraction is the greatest obstacle to overcome. Mr. Lester is perfectly correct in his conclusion that the metal should be pre-heated before and annealed after welding, by passing the flame over the weld, and the metal adjacent thereto. Strains can be created by improper welding equal to a considerable portion of the tensile strength of the metal itself, and this, added to the weakness of a poor weld, would make such welding valueless.

Good steel welding by the oxy-acetylene process will give from 85 to 95 percent of the original strength, and this, of course, can be increased by loading the weld slightly.

The great difficulty in presenting the claims for the oxy-acetylene process of welding is to make those interested understand the necessity for scientific apparatus and the intelligent handling of the same. Almost any mechanic can produce a torch that will mix oxygen and acetylene, but when it comes to the production of pure gases, and a neutral flame under uniform pressure, the longer one works with the torch the more he will realize the difficulty of accomplishing this, and the vital necessity for such conditions.

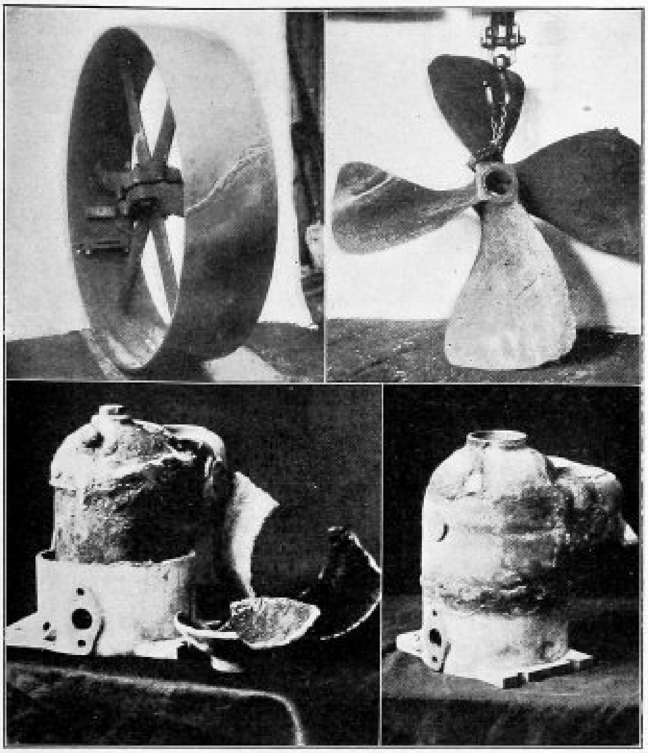
There is no greater field for the oxy-acetylene process than in boiler welding. Two of the largest concerns in the country are now successfully using our process for range-boiler welding and eight pipe-bending companies. It is used by three of the largest steel car builders in car construction, and this is proof that the welds are sufficient in strength for boiler welding, and there can be no question but that intelligence and experience is all that is necessary to make our process invaluable for this purpose.

Augustine Davis, President,
Davis-Bournonville Company.

New York.

Editor The Boiler Maker:

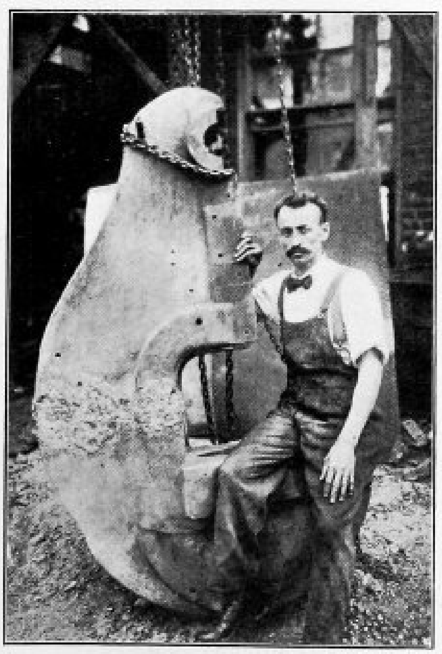
Regarding the practicability of autogenous welding, we enclose photographs of repairs that have been in actual service for various lengths of time and are still in service to-day. These are all cast iron with the exception of the steel pro-



SUCCESSFUL WELDS ACCOMPLISHED BY THE OXY-ACETYLENE PROCESS.

peller. Although we have no photographic data of boiler repairs, we can say that we are welding steel tanks that are subjected to 300 pounds air pressure. An instance of the removal of an oval-shaped section from the head of a tank of ¼-inch plate, and replacing it with the torch as the only tool, may also be seen at our works. This tank is used for oxygen at 150 pounds pressure.

Another example we like to show is what was once a piece of 5-inch iron pipe; in its use a seam opened near the center. This was welded, and recently the cylinder exploded, opening the larger piece that held together until it was nearly flat. This brought out several seams, the seam of special interest being one that stopped at each end of the weld.



A SAMPLE OF HEAVY WORK WELDED BY THE OXY-ACETYLENE PROCESS.

Our percentage of broken welds is very small, and they invariably prove to be due to faulty workmanship. The stress trouble may be overcome in heating. The different metals require different treatment. An expert on steel is seldom as successful on cast iron or aluminum, while an artist on the latter is an exception who can weld steel without burning it.

One man can weld a piece of soft steel to a file, and the file will be broken before the weld will break, while another will be unable, though familiar with the torch, to make the weld hold at the jointure.

We attempt any repair job that can be found; the more difficult the better, in order to better demonstrate the possibilities of the process; and from the really remarkable results obtained we feel amply justified for the claims which we make.

OXY-CARBI COMPANY.

New Haven, Conn.

Retubing a Horizontal Tubular Boiler.

EDITOR THE BOILER MAKER:

As I am a steam and marine engineer, and have had considerable to do with the operation and maintenance of steam boilers, I read with particular interest the article by Henry Mellon, "How to Retube a Horizontal Tubular Boiler," on page 210 of your August, 1909, issue. His method of doing the work is all right, and the time consumed was less than might be expected, but some of the ways of doing the job do not appeal to me as the best that might be brought into use. I do not wish it to be thought for one moment that I am attempting to belittle Mr. Mellon's narrative, nor am I criticising his methods in an unkind or unfriendly spirit. I simply make mention of this so as not to be misunderstood in what I may say, for occasionally you will see articles and letters in the technical papers of the day in which somebody is getting a

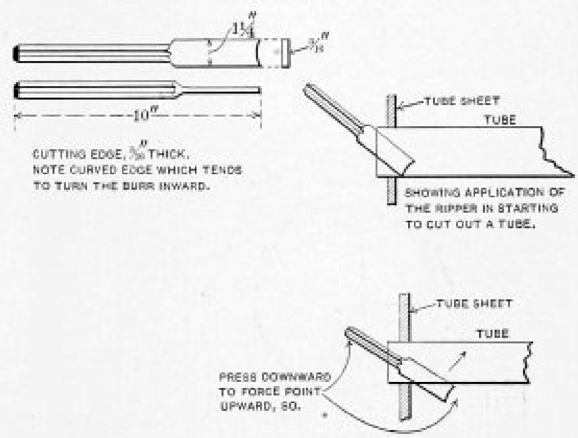


FIG. 1.—RIPPING TOOL, MADE OF HEXAGONAL STEEL ⅞ OR 1 INCH BY ABOUT 10 INCHES.

"call down" because his views are not quite acceptable to the fellow who is acting as a monitor in the matter. Everyone has a certain amount of individuality about him, and he will devise ways and means of doing things that time will prove the value of. Probably Mr. Mellon has tried many other methods of taking out and putting in boiler tubes, and finally decided that the one referred to in his article is the best of all.

While I agree that a diamond-point chisel is an extremely handy tool to have on a boiler repair job, I do not see the need of it in cutting out tubes, as described by Mr. Mellon. Further, would not the driving in of a cape chisel (or any other such tool) between the tube end and its seat in the tube sheet, be liable to mar, to a certain extent at least, the surface of the tube-sheet hole in which the tube end is expanded? I think so, even with the best of care and when used by a most skillful workman. When it is considered that the least nick in the surface of the hole may mean a leak that no amount of expanding will stop, my point, I think, is not far-fetched. Of course, the marred surface can be smoothed up with a half-round or fishback file, but why incur the necessity of the use of such?

A few years ago I participated in the retubing of two 250-horsepower boilers, and the kind of tool that was used and the method of using it is shown in the accompanying sketches.

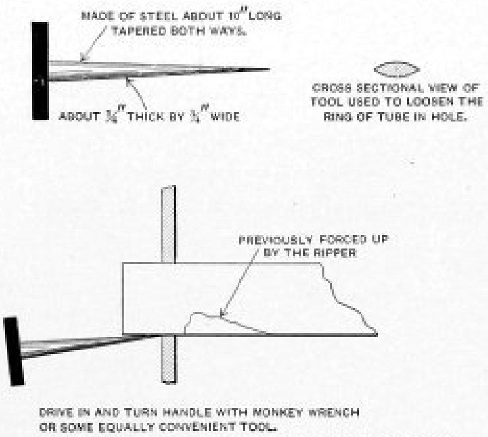


FIG. 2.—TOOL FOR LOOSENING TUBE IN TUBE SHEET.

It is called a "ripper," and it is a very efficient tool in every respect. The cutting edge of the tool is placed inside the tube to be cut out, just back of the inner edge of the tube sheet. Two or three well directed blows of the hammer drive the edge through the tube, yet—owing to the curvature of the cutting part of the tool—no burr is made on the outside of the tube. After the edge of the tool is forced through the tube, then by using the ripper as a lever to be pressed downward, and that part of the tube which is supported by the tube sheet as a fulcrum, the tube is forced inward, thus reducing its size, so that it will easily slip through the hole when it is entirely loosened. Now, there is but a narrow ring of metal in the tube sheet to be loosened up, and the tool used for that purpose is also shown. It will be seen that the cross-sectional shape is oval, and there are no sharp edges or corners that could any way cut or mar the surface of the holes in the tube sheet. This tool is very similar to the splicing needles used by wire-rope workers. It does not require very much force to gain entrance between the ring of the tube end and the hole in which it is, and a few blows of the hammer sends it in far enough, when by turning it the ring is forced inward, and the holding power of the tube end is lost. I think the illustrations will convey to the reader just what I have intended to say concerning the matter.

The tubes were loosened very quickly in the manner referred to, and no trouble of any kind was encountered throughout the entire job, there being 288 tubes removed in that way.

Perhaps if Mr. Mellon had used such tools as I refer to, instead of those he described in his article, he would have completed the job even more quickly than he did. However, be that as it may, there are generally more ways than one to do a piece of work, and we are all the better for learning how the other fellow does it. Exchange of ideas and opinions broadens us and makes us of more value to ourselves as well as to others.

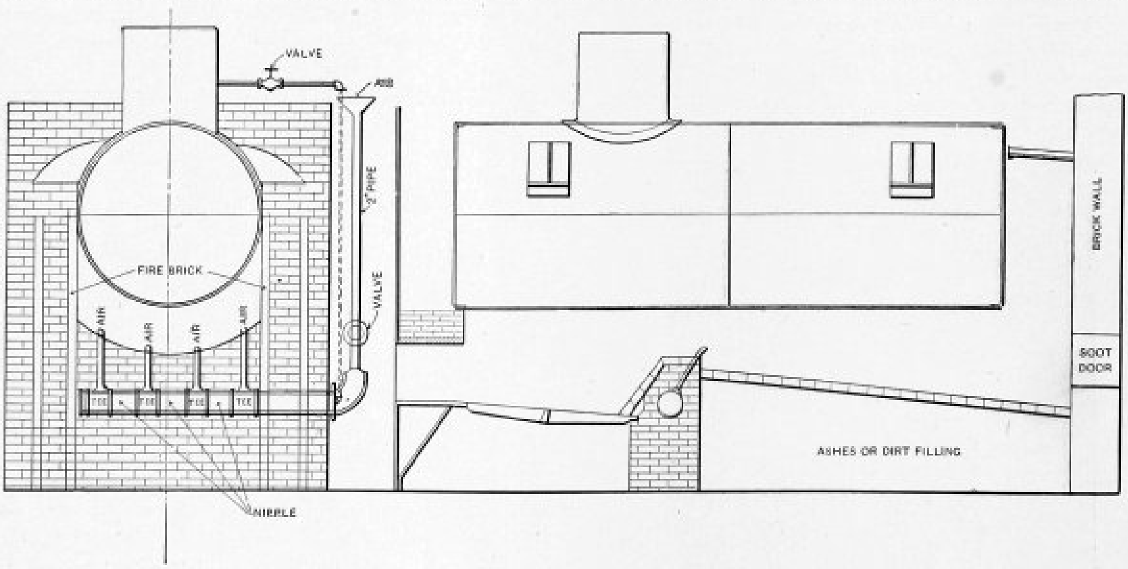
Charles J. Mason.

Scranton, Pa.

A Device to Secure Better Combustion.

Editor The Boiler Maker:

There has been a great deal of agitation about the smoke nuisance in the larger cities. The sketch herewith submitted shows a simple remedy for this nuisance which has been tried and found to be successful. It is a well-known fact that a dense smoke is due to insufficient air passing through the grates to ignite the gases. To effect the combustion of 1 cubic foot of coal gas, 2 cubic feet of oxygen are required, and, as it takes 10 cubic feet of atmospheric air to supply this amount, it will be seen that when the firing is heavy, and a thick bed of coal is on the grate, it will be difficult for sufficient air to pass through. Now, by running a pipe from 4 to 6 inches diameter through the bridge wall with small branch pipes connected, as shown, enough oxygen will enter the combustion chamber to ignite the gases, and a saving in coal will result. A ½-inch pipe can be led from the steam dome to the air pipe, and a small jet of dry steam put in. The pipe should be arranged so that the air supply can be regulated, and also so that nothing can be stuck into the pipe. In arranging the air pipes, as shown, the flames will be deflected from the seam, as that is generally directly over the bridge wall, where the hot gases impinging are apt to make a leaky joint by overheating the outside lap and the points of the rivets so that they come down with the pressure or slip. The branch pipes should be 1 inch diameter, and brought up



SKETCH SHOWING METHOD OF INTRODUCING AIR INTO THE COMBUSTION SPACE OF A BOILER SETTING.

so that they will be about even with the top of the bridge wall. Some exception may be taken to the fact that the air is cooler than the gases; but, as the air does not strike directly on the shell, it will harm nothing; besides, in its passage through the bridge wall, the hottest part in the furnace, its temperature will be raised to very nearly that of the hot gases.

JOHN COOK.

ENGINEERING SPECIALTIES.

The Newest Development in Continuous Annealing and Hardening Furnaces Using Gas or Oil Fuel.

The Rockwell Furnace Company, New York, have recently improved their well-known type of internally-fired rotary furnace, in order to give greater flexibility in the range of work handled by it and to add to its durability. Heretofore these furnaces were built only with special-lining brick, which formed deep, helical channels, with separating spiral walls for feeding the material forward. This arrangement worked very well for light, smooth pieces, such as lock washers, balls, etc., but was found to be unsuitable for long pieces, such as bolts, rivets, etc., and irregular-shaped steel punchings, forgings, castings, etc.

In the present type of furnace, for smooth or round work, the rotating cylinder or drum is lined with a standard, hard, refractory brick, with a smooth internal surface. The furnace is mounted in such a manner that its axis may be tilted at an angle, giving the revolving hearth an incline with the discharge end lower than the entrance or feed end. The gradual incline causes the material to feed forward, and by means of a hand wheel the degree of pitch may be adjusted so as to regulate the progression of the material through the furnace and consequently the time of heating.

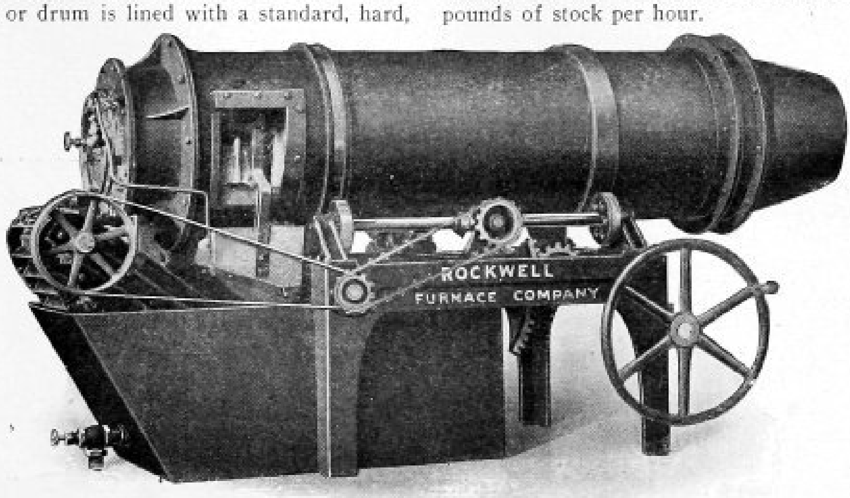
The advantages of this method of automatic continuous heating, it is claimed, are many; the material is charged in bulk in a hopper at the exhaust end of the furnace and fed automatically into the chamber; the material comes continually in contact with the newly-heated surface of the chamber, which is revolving, thereby absorbing the heat from the lining as well as from the heated gases. In a stationary furnace the heat from the sides and roof are not utilized, as the material remains in a fixed position; that farthest removed from the heat requires a much longer period to be brought to the desired temperature, and the more exposed pieces are liable to overheating, others being insufficiently heated, and the whole requiring a much longer time.

In operation, the pieces are fed continuously into one end of the cylinders. The furnace is fired internally from the opposite end, with the zone of highest temperature at the discharge end. The cylinder revolves slowly (1 to 4 revolutions per minute), and owing to the slight inclination of the furnace the pieces treated fall slightly forward at each revolution, gradually progressing toward the discharge end, where they enter a proper receptacle or bath upon reaching the desired temperature. To prevent oxidation, the end of the discharge spout may be carried beneath the level of the bath, thereby sealing it and excluding the air.

By this method it is claimed that clogging or retardation of the work is avoided, as there are no corners or pockets in which the pieces can lodge. Wear of the lining is reduced to a minimum, and does not require renewal until the greater portion of the brick is worn away. In certain classes of work, such as balls, nuts and uniform shapes, the helical or worm type is used, and this furnace may be lined either way, as preferred, but where the smooth lining can be used the cost is less and a greater life is insured.

Oil or gas fuel may be used, and perfectly uniform results obtained, as the work treated is heated gradually, with every portion of its surface exposed to the direct action of the hot gases and lining, and both temperature and time are maintained constant.

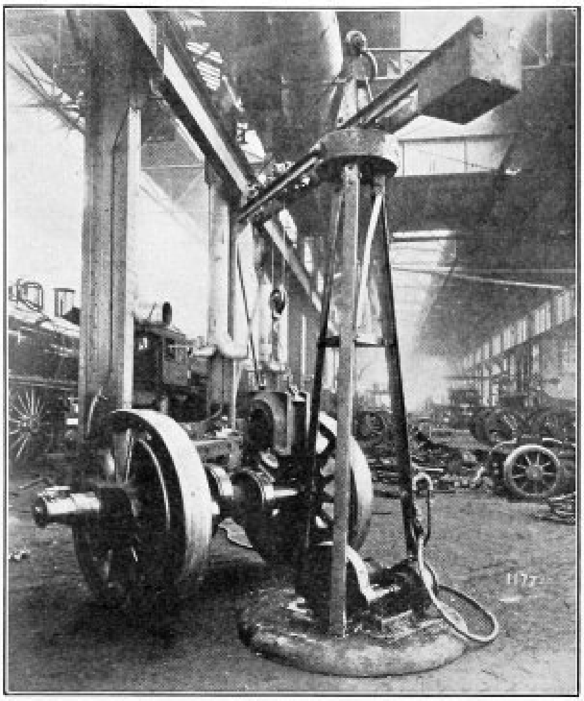
These furnaces are built to suit a wide range of requirements, and in sizes at present that will handle up to 2,000 pounds of stock per hour.



A New Portable Jib Crane.

The portable jib crane herewith illustrated was designed by a master mechanic on one of the largest railroads in the country, and has been successfully tried in the erecting shop. It may be placed in any position on the floor by an overhead traveler in a moment's time, and will handle loads without any manner of assistance from the traveler. Thus not only is the labor of the men engaged on a given job rendered more efficient, but the time of the traveling crane is effectually conserved. On account of its flexibility of location, a crane of this type should be popular in many lines of shop work. The work for which it is suited in railroad shops, for instance, includes the removal of driving boxes, eccentric straps and eccentrics from driving axles, and, after repairs have been made, of refitting these parts to the axles. All work in connection, such as putting up the collars, sponging boxes and bolting the eccentrics and eccentric straps, is done under the crane. It is said that one of these cranes will serve a shop handling sixty engines a month for average repairs, and from actual experience will save the labor of one mechanic and two helpers, amounting to about $200 per month. Besides this economy, much of the time of the traveling crane is available for other operations, which could not be performed by one auxiliary crane, thus greatly increasing the commercial efficiency of the more expensive tool.

This crane can also be used advantageously in a locomotive boiler shop for handling the pneumatic gap riveter, or staybolt breaker, as well as in the machine shop for assembling tools and for handling heavy vise work. In almost every shop there are fitting and assembling operations on the floor which



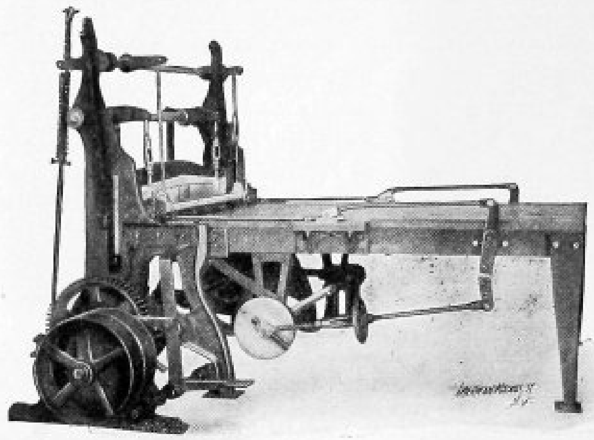
call for crane service, and in the absence of some such device as that shown the traveler must be used, with consequent delay to other operations.

The crane consists of a heavy, attached top, to which a rotating jib, stayed by tension rods, is pivoted. A movable trolley is provided, which supports a block, and a weight attached to the opposite end of the jib balances the trolley and part of the load. At the head of the pillar is fitted an eyebolt and shackle for handling the crane by the overhead traveler. The hoisting gear is attached to the base plate or structural pillar, and is operated by a pneumatic or electric motor or by hand power. The swinging and trolley travel are operated by hand power.

These cranes are manufactured by the Whiting Foundry Equipment Company, Harvey, Ill.

An Automatic Feeding Shear.

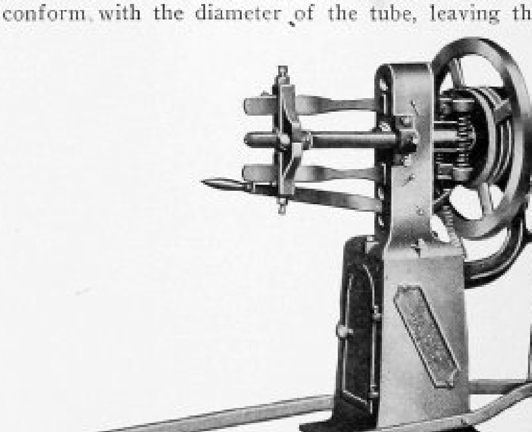
A new shear has recently been designed and built by Bertsch & Company, Cambridge City, Ind., which has an automatic feeding mechanism for automatically feeding a sheet into the blades. It can be adjusted so that it will automatically shear a sheet into uniform strips of any desired width from 1/16 inch to 12 inches. It is claimed that the feeding mechanism is accurate and positive. It consists of an eccentric on an auxiliary shaft suspended under the table, which is driven from the main drive shaft and connecting rods and a clamping device; all of which is clearly shown by the half-tone. The clamping device consists of two plates or jaws, which grip the sheet and hold it securely at the proper time. It moves away from the blades while the clamps are open, then grips the sheet and moves toward the blades, thus feeding the sheet automatically. At the instant the feeding mechanism places the sheet in the desired position to be sheared, the regular hold-down descends ahead of the top knife, and holds the sheet in place during the shearing. While the shearing is being done the plates or jaws of the feeding mechanism relieve their grip, and move away from the blades into a position ready to grip and feed the sheet for the next cut. The plates or jaws which grip the sheet are opened and closed by means



of an eccentric on the main driving shaft, which actuates the overhead connecting arms and rods shown by the illustration. Either a single sheet of any width up to the length of the blades, or several narrower sheets, placed side by side, can be fed automatically. The manufacturers can also attach their automatic feeding mechanism to any of their standard shears.

The Herschell Automatic Hand and Power Flue-Welding Machine.

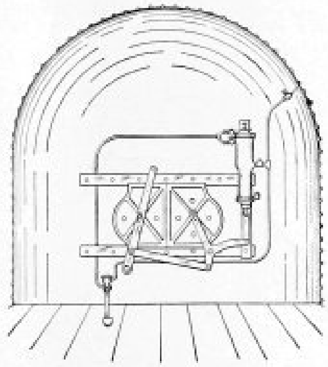
This machine, which is manufactured by J. T. Herschell, Princeton, Ind., is designed for welding boiler tubes from 1¼ to 4½ inches diameter. The mandrels are so made that the tube will fit when cold, but when heated for welding will be expanded sufficiently to go on easily. The hammers are made to conform with the diameter of the tube, leaving the tube



smooth inside and out. The long lever, shown in the illustration, is only used when the tube is allowed to remain too long on the mandrel. By bracing down the lever it will lock the bottom hammer. The top hammer will then do the striking, which will loosen the tube. The power machine can be operated by hand, by taking off the back bracket and friction clutch and putting on a crank. The capacity of the machine is rated by the number of tubes that can be heated. It has a speed of from 125 to 135 per minute.

The Shoemaker Pneumatic Fire Door Operator.

The Shoemaker fire-box door operator is a device which accomplishes the desired result in a simpler and surer manner than other similar devices on the market. It differs from the other automatic fire-box door operators in not having double cylinders for opening and closing the door, and it has no spring movement to close the door. The improved device here illustrated opens and closes the door with a single cylinder fitted with a differential piston, and no springs are used in connection with it. The door is opened and closed in a



uniform length of time, regardless of the air pressure carried, and is so designed that the action is cushioned so as not to permit slamming and possibly consequent breaking of the doors. The strong claim for this door operator is its simplicity of design, permanence of action and material reduction of firemen's labor.

It is supplied by the National Railway Devices Company, 400 Old Colony building, Chicago, Ill.

A New Hydro-Carbon Burner.

Wherever Pintch gas is manufactured by railroads there is a great quantity of refuse which commercially is known as hydro-carbon. This can be used in burners for various shop operations, as shown in the following illustrations: Fig. 1 shows a burner in actual operation with hydro-carbon heating the corners of a locomotive boiler, while Fig. 2 shows the same burner heating a locomotive frame for straightening.

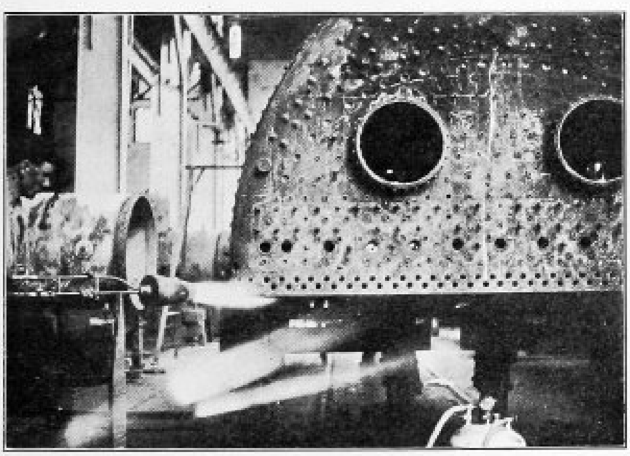


FIG. 1.

The construction of this machine is very simple, and it is claimed that it is absolutely reliable, and can be handled safely by any workman, and that it gives a clear flame. An important feature of the burner is that it can be changed with a slight alteration, so that it can be used successfully with any liquid fuel. The machine is principally useful for the construction

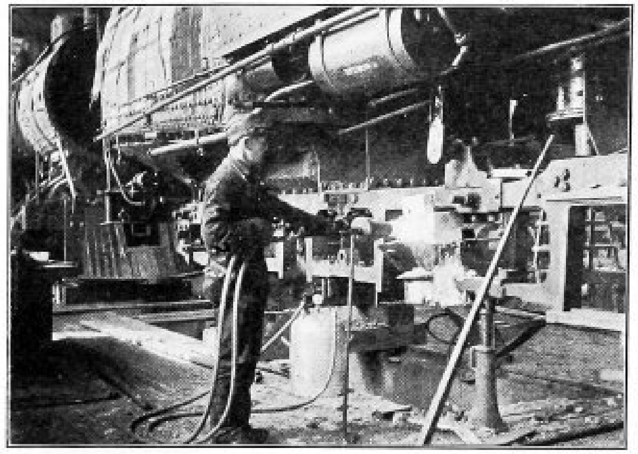


FIG. 2.

and repair of steel cars, straightening and welding of engine frames, for pre-heating in connection with thermit welding, in the construction and repair of boilers for brazing and various other heating operations.

The manufacturers are the Hauck Manufacturing Company, New York City.

The Little Giant Combined Punch, Splitting Shear and Rod Cutter.

This machine weighs only 350 pounds, and occupies a floor space only 23 by 20 inches, yet it will split sheets up to ⅛ inch, will cut bar-iron ¼ by 2½ inches, will punch a 5/16-inch hole in ¼-inch iron, or will cut a round bar up to ½-inch diameter. The punch is operated independently from the shear, the machine being furnished with a lever for each. Therefore, two operators can use the machine at the same time; for they can work without interfering with each other. Both levers work towards the operator. The punch is equipped with a stripper and two gages, the die overhangs the body of the machine, and it is possible to punch stacks or bands 7 inches in diameter, or more, and 2 inches from the edge.

The shear arm and levers are cast steel, and the shear blades

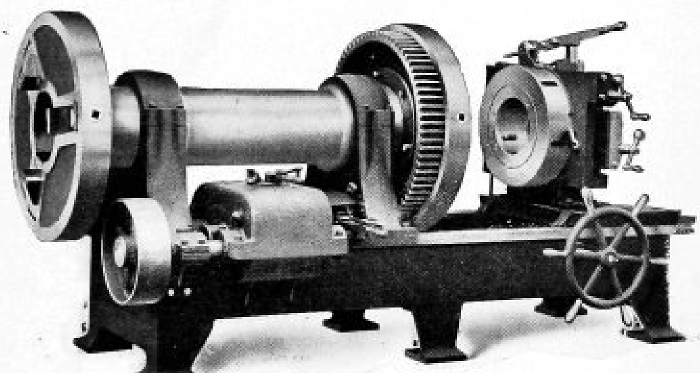
are 10 inches long. The body of the machine is cut away, so that in splitting the sheets will pass without binding. The machine stands at the proper height for easy access of both punch and shear, and the levers are at a convenient height for the operators. This tool is manufactured by the Little Giant Punch & Shear Company, Sparta, Ill.

The H. & B. Steam Drier.

In the description of the H. & B. steam drier, which we published last month, we neglected to state that the manufacturers, Ed. C. Garratt & Company, are located at 102 South Clinton street, Chicago, Ill. It will be remembered that this steam drier is a device which is applied to the inside of a boiler directly under the main stop valve, and which allows water that is drawn up mechanically by the current of steam passing from the boiler into the steam pipe to return by gravity before reaching the steam pipe.

A Duplex Improved Pipe Machine.

This machine is designed to cut off and thread pipe or casing from 2½ inches to 8 inches, inclusive. The die head is of the low-down type, placing the handles and die lever within easy reach of the operator. It is equipped with the Peerless adjusting mechanism, which is very simple to operate. The adjustments necessary to obtain threads of different gages are made by turning the adjusting nut. This nut is attached to the cam ring bracket by means of a swivel yoke. The adjusting screw passes through the nut and is connected to the die lever. Turning the nut in either direction revolves the cam ring, causing the dies to expand or contract. When the die lever is down, in position for threading, it is in a straight line with the adjusting screw, which means that the dies release with the first upward movement of the die lever. There can be no digging into the pipe. When the dies are to be removed from the head, the stop latch is thrown back, allowing the cam ring to revolve into such a position that the openings in the ring are opposite the slots in the die head. The dies can



then be removed. This also permits the slots to be cleaned without removing the ring. The steady slides, which support the pipe when being cut off, have interchangeable hardened steel facings. On one of the slides is attached the cutting-off device, which places the cutting-off tool near the point of support. When it is desired to cut off pipe, the steady slides are closed on the pipe firmly, and the cut-off tool is then brought into action. The reaming tool is held in a tool post on the cut-off slide, and is always in position. The chucks are of the independent type, each having three jaws. Tempered steel grippers are dovetailed into the ends of the slides, and can be removed and sharpened. The slides, which are made of steel, are graduated and readily set to any particular size. The slides on the rear chuck have flange grippers in addition to the pipe grippers, for making up flanged work. The speeds are obtained through the gear box and a compound sliding gear on one of the shafts. There are no rocking gears or clutches. The gears in the box are made of steel and run in oil. A speed plate is attached to the box, showing how to obtain the speeds for the various sizes of pipe. By using a single driving pulley a constant belt speed is obtained.

The manufacturers are the Bignall & Keeler Manufacturing Company, Edwardsville, Ill.

SELECTED BOILER PATENTS.

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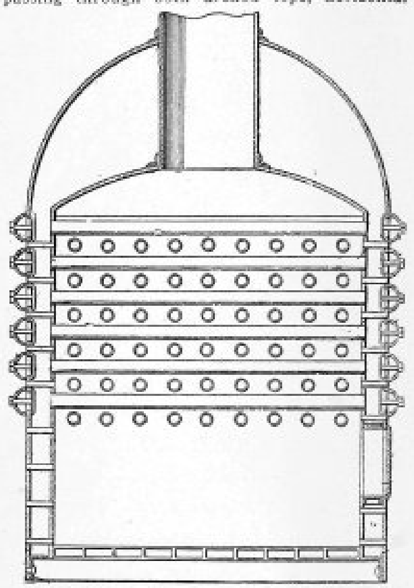
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

928,907. FURNACE. CHARLES F. DILLER, OF LANCASTER, PA.

Claim 1.—A device, including a header and an air supplier communicating with said header, and consisting of spaced-apart tubes united at their upper and lower ends to form a single casting, with the separating space forming a flame passage, partly flared rearwardly and partly flared forwardly, being narrowest at the center, said tubes having air apertures in their rearwardly converging portions. Three claims.

930,341. BOILER. WALTER AUTHER BERRY, OF CHATTANOOGA, TENN., ASSIGNOR OF ONE-HALF TO RAYMOND W. FRAWLEY, OF CHATTANOOGA, TENN.

Claim.—A boiler or water heater comprising vertical inner and outer rectangular shells united at their bottoms by means of a double right angled flange, arched tops covering both the inner and outer shells, a smoke flue passing through both arched tops, horizontal water tubes



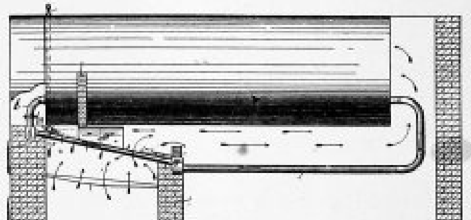
crossing each other secured to the inner shell and uniting water spaces between the inner and outer shells, clean out openings provided with covers located in the outer shells opposite each water tube opening, the upper clean out openings being so located as to afford access to the space between the arched tops covering the shells, for removing accumulations therebetween, and stay-bolts arranged in horizontal and vertical rows connecting the inner and outer shells and located between the clean out openings so as not to interfere therewith. One claim.

928,933. LOW-WATER ALARM FOR STEAM BOILERS. CHARLES BRENT, OF BRANDON, MANITOBA, CAN.

Claim 1.—In a low-water alarm for steam boilers, in combination with an alarm system, of a head in open communication with the boiler, means for supplying steam from the boiler to said head whereby upon the water in the boiler sinking below a certain point, steam will pass into said head and convert the same into a steam head, and a thermostatic device surrounding said head and adapted when said head is converted into a steam head to cause the alarm to operate. Three claims.

929,624. UP-DRAFT FURNACE. OREL D. ORVIS, OF BAYONNE, N. J., ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE UNITED STATES COAL SAVER & SMOKE CONSUMER COMPANY, OF AUGUSTA, ME.

Claim 1.—In an up-draft furnace the combination of a boiler, a fire-box below the same, a firebrick wall at the rear of said fire-box, a transverse square header supported in said wall, a second square header supported in the front wall of the furnace, inclined watertubes connecting said headers, arched retorts above and supported by the said inclined tubes, the said retorts being located about midway between the



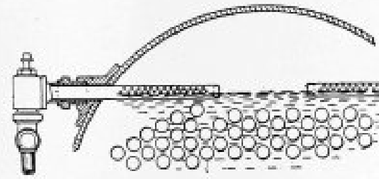
front furnace wall and the said firebrick wall, a transverse jet pipe, jets in said pipe adapted to eject fresh, hot air into and through said retorts, connections between the said jet pipe and said boiler, a layer of bricks supported on the rear ends of the said inclined watertubes, a vertical wall above the first mentioned square header and connections between the said headers and the boiler. Two claims.

928,962. FEED-WATER HEATER. WILLIAM W. GRINDLE AND JARED S. SWEENY, OF DECATUR, ILL.

Claim 3.—In a feed-water heater, the combination with the shell having a water chamber and a steam chamber, water and steam inlet valve seats in the walls of their respective chambers, valves thereon having stems, and a rocking lever pivoted to the shell with its arms engaged by said stems; of a water inlet leading to, and a water outlet leading from, its chamber, a nozzle leading from the steam chamber and directed into the water outlet, a jacket cast around the shell and providing a steam passage communicating with the steam inlet valve, and a steam inlet pipe leading to said passage. Four claims.

929,716. MEANS FOR INTRODUCING FEED-WATER INTO STEAM BOILERS. CHARLES W. SEDDON, OF PROCTOR, MINN., ASSIGNOR OF ONE-HALF TO JOHN E. CHISHOLM, OF OELWEIN, IA.

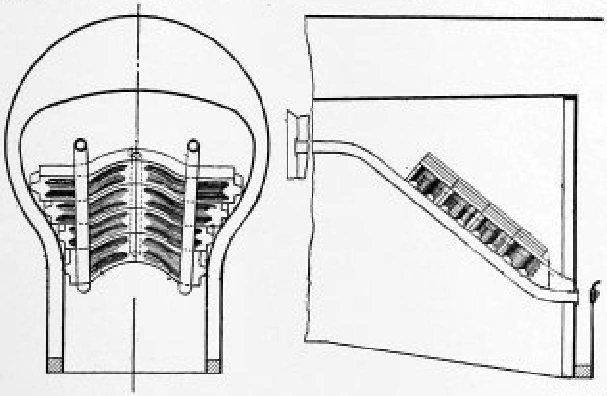
Claim.—In a steam boiler, the combination with the shell thereof having an opening, and a bracket arranged about said opening, of a check valve, a feed-water pipe carried by said check valve and supported thereby within the bracket, whereby to be removed bodily with



said valve when the latter is removed from said bracket, said feed-water pipe projecting into the steam space of the boiler and having its inner end closed, the upper portion only of the feed-water pipe being perforated to spray the feed-water in an upward direction into the steam space, and means for connecting the check valve to said bracket. One claim.

929,724. FIRE-BRICK ARCH. ENOCH P. STEVENS, OF CHICAGO, ILL.

Claim 1.—A fire box, in combination with an arch consisting of a plurality of rows of fire bricks, each row containing a plurality of bricks respectively provided with longitudinal recesses on the under and upper faces thereof, such recesses terminating short of the meeting



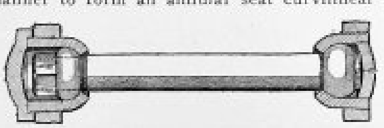
edges of the rows of bricks, and with transverse recesses at their meeting edges, and a bar between the meeting edges of the brick in the transverse recesses thereof, arranged to bind the meeting bricks of all the rows together. Five claims.

930,200. SPARK ARRESTER. HERMANN LIECHTY, OF BERNE, SWITZERLAND.

Claim.—In a device, the combination with a smoke box provided with a stack, of an upper and lower ring located therein and spaced apart, wings journaled between said rings, an upright plate connecting the rings at the back of the smoke box, a shield projecting forwardly from the lower ring, a blast pipe opening into said lower ring, and means of communication between the stack and the space between the rings. One claim.

930,807. STAY-BOLT. WILLIAM M. SMITH, OF TURTLE CREEK, PA.

Claim 1.—In combination, a pair of oppositely disposed tapering hollow plugs having peripheral threads for connection to the opposite sheets of a boiler, said plugs open from end to end, said plugs projecting inwardly from the inner faces of the boiler sheets, each of said plugs having the body portion thereof at its inner end inturned in a curvilinear manner to form an annular seat curvilinear in longitudinal



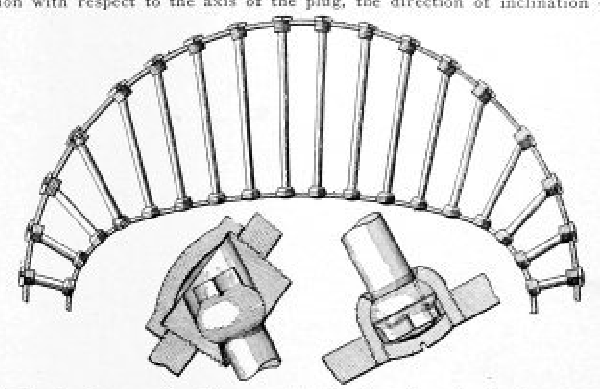
section and whereby the inner edge of the body portion will be flared with respect to the axis of the plug, said flared inner edge projecting from the inner terminus of said curvilinear seat, said seats arranged in a plane inwardly of the inner faces of the boiler sheets, removable means for closing the outer ends of said plugs, and a bolt having a head at each end, each of said heads having a portion thereof rounded to constitute a bearing surface, said surfaces engaging the seats of the plug and adapted to shift thereon on the expansion of the boiler sheets, said flared inner edge of said plugs providing a clearance for the shank during the shifting of the heads upon said seats. Four claims.

930,360. FURNACE FRONT AND DOOR. THOMAS DOWNIE, OF WALLASEY, AND DAVID BROWN, OF BOOTLE, ENGLAND.

Claim 1.—A furnace front comprising a casing, two interior vertical walls in the upper part of said casing extending from front to rear, and a horizontal wall connecting the lower ends of said walls, said interior walls dividing the case into outer and inner chambers, controllable means for admitting air to said chambers, and vertical and horizontal walls formed in one piece removably secured to the casing and fitting in the inner chamber and forming a fuel opening, said removable walls being perforated. Three claims.

930,809. FLEXIBLE STAY-BOLT. WILLIAM M. SMITH, OF TURTLE CREEK, PA.

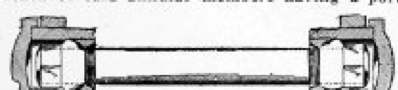
Claim 1.—The combination with a roof sheet of a boiler and the crown sheet of a fire box, of coupling plugs secured in the roof sheet at an inclination and each provided with a bore extending at an inclination with respect to the axis of the plug, the direction of inclination of



the bore being opposite with respect to the direction of inclination of the plug, the wall of each of said bores provided with annular seat, coupling plugs secured to the crown sheet and provided with seats, and staybolts having heads at each end provided with bearing surfaces engaging the seats of the plugs whereby the bolts are flexibly connected with the said sheets by said coupling plugs. Twenty-two claims.

930,810. STAY-BOLT. WILLIAM M. SMITH, OF TURTLE CREEK, PA.

Claim 1.—In a flexible stay means for boiler sheets, a pair of hollow bearing plugs adapted to be secured to the opposite sheets of the boiler, an annular member detachably secured in each of said plugs at the inner end thereof, each of said annular members having a portion of its in-



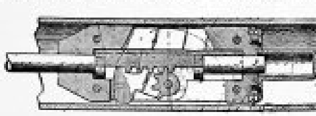
ternal face provided with an annular seat curvilinear in cross section, the remaining portion of the internal face of each of said annular members flaring, and an adjustable bolt having a head at each end provided with a bearing surface, said bearing surface engaging the seats of the said annular members and adapted to shift thereon on the expansion of the boiler sheets. Four claims.

931,046. FEED-WATER HEATER. WILLIAM S. FERGUSON, OF LEESVILLE, LA.

Claim.—An arch for heating boiler furnaces comprising a series of bars, each having at its upper and lower ends outwardly projecting flanges, the upper flanges being engagable with the end wall of the boiler above the tubes, and the lower flange being supported on the rear wall of the furnace, and said arch also extending at its ends up to the side walls of the furnace, whereby the space between the rear end of the boiler and the side and rear furnace walls is completely bridged over; and each of said bars having a sinuous passage through which the feed water flows, each of said passages having an inlet at one end and an outlet at the opposite end of the bar, a connection between the inlets and the outlets of adjoining bars, whereby a continuous passage through the entire length of the arch is had, an outlet from the passage at one end of the arch, and an inlet at the opposite end thereof. One claim.

931,245. BOILER-TUBE CLEANER. JOHN ZILLIOX, OF BUFFALO, N. Y.

Claim 1.—The combination of a rotatable casing having a hammer-chamber, a swinging hammer arranged in said chamber, and a con-



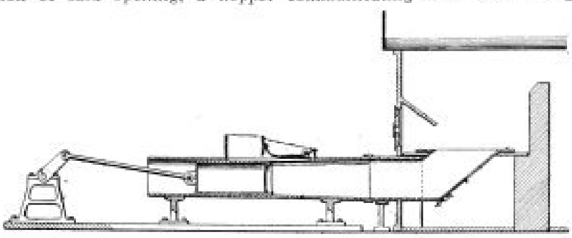
tinuous rod extending through the rear of the casing, slidable lengthwise thereof and having means for positively connecting the rod with the hammer, said rod being non-rotatable relative to said casing. Twelve claims.

931,095. DAMPER REGULATOR. GABRIEL STEELE, OF SIOUX CITY, IA., ASSIGNOR OF ONE-HALF TO FRED L. EATON, OF SIOUX CITY, IA.

Claim.—The combination with a steam boiler and furnace, of a rock bar, a hanger pendent from said rock bar and held against the door of said furnace, a vertically disposed cylinder secured to said furnace, a piston within said cylinder, a rod extending from said piston in opposite direction through the ends of said cylinder, a feed pipe extending from said boiler and entering the lower end of said cylinder, a three way valve within said feed pipe connected to said rock bar, an exhaust pipe extending from said valve, an overflow pipe leading from the upper end of said cylinder and connected to said exhaust pipe, a waste pipe extending from the union of said two pipes, a weighted crank provided with a damper within the smoke flue of said furnace, a pliable connection extending from said upwardly projecting piston rod and secured to said crank, and a weight secured to the downwardly projecting end of said piston rod, said weight being in excess of the weight upon said damper. One claim.

931,536. UNDERFEED FUEL-STOKER. GUSTAVE WEILAND, OF STOCKTON, CAL.

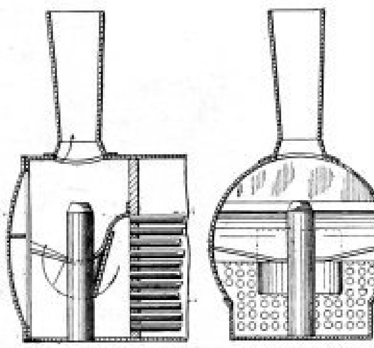
Claim 2.—In an under feed fuel stoker, the combination of a feed tube adapted to be arranged in the ash pit of a furnace, and to open into the fire box thereof, a plunger cylinder adapted to be connected to the outer end of said feed tube, said cylinder having an opening formed in its upper side, a flange arranged around three sides of a portion of said opening, a hopper communicating with the unflanged



portion of the cylinder opening, a hinged plate adapted to close the flanged portion of said opening and having an upwardly curved end to bear against the front of the hopper and form a closure for the opening therein, a spring arranged to yieldably hold said plate in closed position, a plunger slidably mounted in said cylinder, and means for reciprocating said plunger. Two claims.

931,727. INTERIOR ARRANGEMENT FOR SMOKE-BOXES OF TUBULAR BOILERS. FRIEDRICH WILHELM BORN, OF CHARLOTTENBURG, GERMANY.

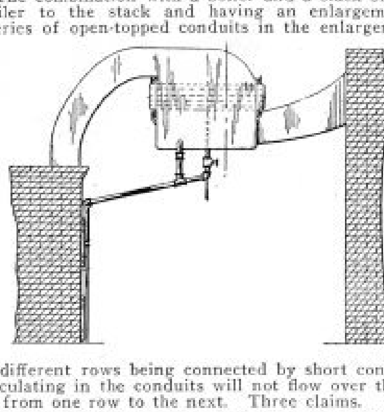
Claim 2.—In a steam boiler furnace the combination of a smoke box, fire tubes leading thereto, an exhaust nozzle situated therein, and baffling means, the upper portion of which extends from above said fire tubes downwardly and away from the same to a point adjacent the exhaust nozzles, causing the products of combustion from the upper tubes to pass downward and around the lower edge of said upper por-



tion, the lower portion of said baffling means being situated in front of the middle fire tubes and having its sides curved away from said tubes, the gases which pass around the sides thereof intermingling with those that pass through said upper fire tubes, the ends of the fire tubes at the sides of the lateral edges of said lower portion of the baffling means and below the bottom edge of said portion being free, the middle part of the uper portion being removably disposed in the smoke box. Four claims.

931,788. MEANS FOR REMOVING SOOT AND SPARKS FROM SMOKE PASSING THROUGH FLUES. JOHN McLAUGHLIN, OF OTTAWA, ONT., CANADA.

Claim 3.—The combination with a boiler and a stack of a flue leading from the boiler to the stack and having an enlargement therein, a continuous series of open-topped conduits in the enlargement, arranged



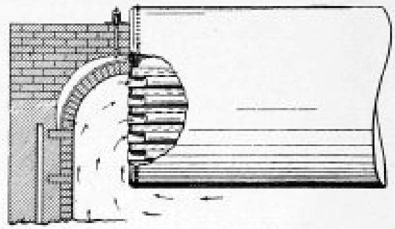
in rows, the different rows being connected by short conduits, whereby the liquid circulating in the conduits will not flow over the edges thereof in passing from one row to the next. Three claims.

932,007. FEED-WATER REGULATOR. HARRY EVANS, OF BRYN MAWR, PA.

Claim 2.—The combination of a boiler, a water feed pipe communicating therewith, a valve casing included in said feed pipe, a valve in said casing controlling said pipe, a stem projecting from said valve, an expansion tube connected to said stem, yielding means for forcing said stem and tube outwardly, and means to limit the outward movement of the stem and tube. Five claims.

931,834. RIB FOR BOILER ARCHES. ERNEST W. ASHENDEN, OF MINNEAPOLIS, MINN., ASSIGNOR TO WM. BROS. BOILER & MANUFACTURING CO., OF MINNEAPOLIS, MINN., A CORPORATION OF MINNESOTA.

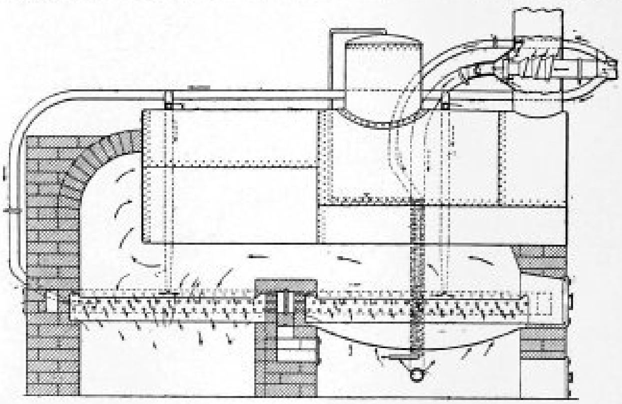
Claim 1.—The combination, with a boiler setting, of a horizontal tubular boiler, a combustion chamber being formed beneath said boiler and at the end thereof, said combustion chamber having an arch comprising curved ribs seated at one end in the said setting and bearing at their opposite ends on the boiler flue sheet, and said ribs having inwardly turned ends with seats formed thereon, and webs in the angles



formed by said ends, and fire brick fitted between said ends and forming the top of the arch and separating said ribs from the flame and hot gases. Two claims.

931,952. STEAM-BOILER FURNACE. WILLIAM GURLEY MUNSON, OF INDIANAPOLIS, IND.

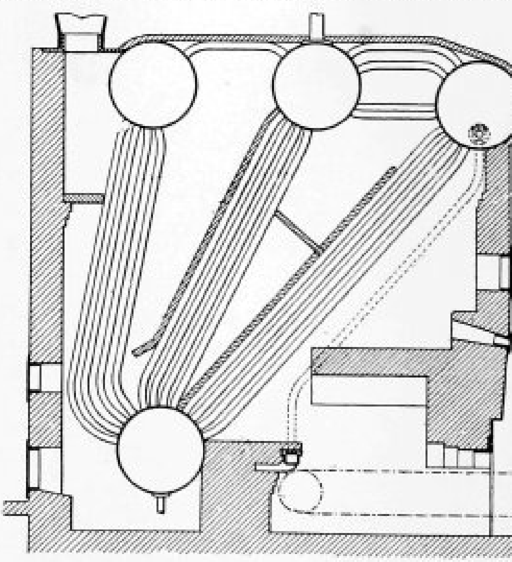
Claim 1.—The combination in a steam-boiler furnace, a grated and a non-grated combustion chamber, a bridge wall dividing the combustion chambers, the walls surrounding and forming the combustion chambers



having conduits which are divided longitudinally into separate communicating passages, and the said chamber walls having perforations opening into the inner passages of said conduits and into said chambers, and means for forcing air into a division of the conduits. Seventeen claims.

932,369. BOILER STOKER. JOHN E. BELL, OF NEW YORK, N. Y., ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

Claim 1.—In a tubular boiler furnace having upper and lower water drums, an upwardly projecting bridge wall having above it an outlet for flame and gases, a transversely extending water-back in said bridge



wall, and direct connections betwen opposite ends of the said water back and an upper drum arranged to produce a down circulation in one connection and an up circulation in the other connection. Eight claims.

932,044. FURNACE. FREDERICK H. C. MEY, OF BUFFALO, N. Y.

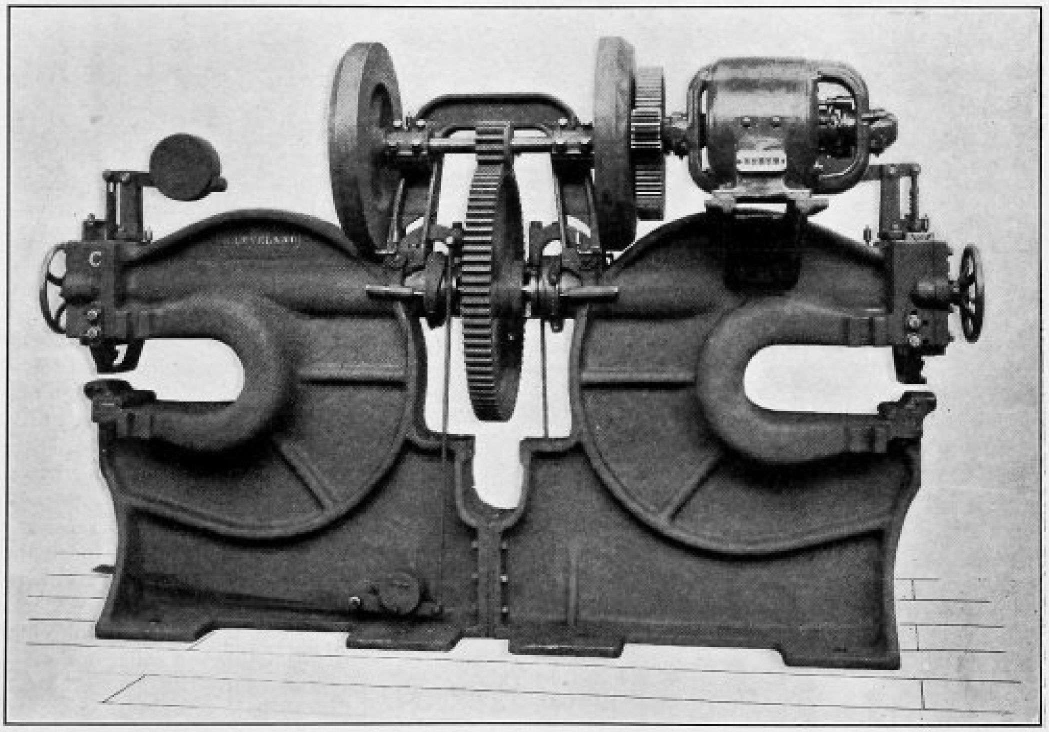
Claim 1.—In a furnace, the combination of the combustion chamber, a mixing chamber communicating with the combustion chamber, a cold air flue also connected with said mixing chamber, and a single valve applied to the rear portions of said combustion chamber and said cold air flue and constructed to open communication more or less between the mixing chamber and the cold air flue when communication between the combustion chamber and the mixing chamber is partly cut off, or vice versa. Four claims.

THE BOILER MAKER

NOVEMBER, 1909

INDIVIDUAL ELECTRIC MOTOR DRIVE IN BOILER SHOPS.

The fact that the installation of an individual motor drive for the operation of various machine tools represents an investment 15 or 20 percent in excess of that required for a group drive may cause persons contemplating the installation of machine-shop equipments to hesitate in adopting this form of drive, yet boiler and blacksmith shops may be placed in the same category with planing mills, where the cost of installing independent motors is less than that required for any mode of operation, because of the constant speed service characteristics and consequent simplicity and low cost of applying motors to the various machines.



DIRECT ELECTRIC MOTOR DRIVE APPLIED TO DOUBLE-ENDED PUNCH.

A modern boiler-shop equipment includes traveling-crane facilities for handling material, rendering it necessary to leave the space between crane girders and machinery clear. In view of this fact the elimination of line shafting and belting becomes absolutely imperative.

The recent introduction of gas-electric riveters, punches, shears, etc., constitutes another very strong argument in favor of the installation of the independent drive in boiler and blacksmith shops. These machines require a small motor as an auxiliary power unit, the pressure for riveting, punching, etc., being obtained, however, from the explosion of a gasoline mixture in a closed cylinder.

In order to handle the long flues, plates, and bars, the various machines are a comparatively great distance apart, necessitating the use of an exceptionally large amount of shafting and belting for a group drive and involving excessively large losses, notably so when carrying a partial load. Certainly a great increase in the output and a great reduction in operating costs is effected by making each tool an independent unit.

Practically all boiler and blacksmith shop machinery can be classed as constant speed, with requirements varying from 1½-horsepower for a single head stay-bolt cutter to 50-horsepower for large bending rolls.

The following table contains the more important machines, together with the size of the motor applicable to the various capacities of each type:

	Capacity		Horse-Power of Motor
	Hole	Plate	
Punches	½ in.	½ in.	3
	1 in.	½ in.	5
	1 in.	1 in.	7½
	2 ins.	1 in.	10
	2½ ins.	1½ ins.	15
	4½ ins.	1½ ins.	25
	6 ins.	1½ ins.	30

	Capacity Plate	Horse-Power of Motor
Shears	3/16 in.	1
	1/4 in.	2
	3/8 in.	2 1/2
	1/2 in.	4
	5/8 in.	5
	3/4 in.	7 1/2
	7/8 in.-1 in.	10
	1 1/4 ins.	15
	1 1/2 ins.	20

Note.—Double-ended machines require 10 to 20 percent more power than single machines.

	Plate	Horse-Power of Motor.
Bending rolls	6 ft. x 5/16 ins.	5
	6 ft. x 7/16 ins.	7 1/2
	6 ft. x 3/4 in.	15
	8 ft. x 7/8 in.	25
	10 ft. x 1 1/8 in.	35
	10 ft. x 1 1/2 ins.	50
Power drop hammers	15 lbs.	1
	30 lbs.	1 1/2
	50 lbs.	2
	75 lbs.	2 1/2
	100-125 lbs.	4
	150-200 lbs.	5
	500 lbs.	10
Flue rattlers		15-25
Flue welders		5
Flue cutters		3- 5
Gas-electric riveters 1 1/4 ins		2

	Capacity.	Horse-Power of Motor.
Bolt, nut and forging machines	3/4 in.	5
	1 in.-1 1/4 ins.	7 1/2
	1 1/2 ins.	10
	2 ins.	15
	2 1/2 ins.	20
	3 ins.	25
	4 ins.	30
	5 ins.	35
	6 ins.	40
Bolt cutters (single)	1 in.-1 1/2 ins.	1 1/2
	2 ins.	2
	2 3/4 ins.-3 1/2 ins.	3
	4 ins.-6 ins.	5
Bolt cutters (double)	1 in.-1 1/2 ins.	2
	2 ins.-2 1/2 ins.	3
Bolt cutters (triple)	1 in.-2 ins.	3
Nut tappers	1 in.-2 ins. 6 spindle	3

The power required for operation of blowers varies so greatly, depending upon blast, pressure, number of forges, and general installation, that no attempt has been made to incorporate them in the table.

In view of constant speed requirements, alternating current motors should be used, if possible, on account of their simplicity and reliability.

Uniform Boiler Laws in Canada.

Boiler manufacturers in Canada are meeting with more success in their fight for uniform boiler laws than are those in the United States. Although at present each province of Canada has its own laws, and these are all different, yet the manufacturers and others interested have become so thoroughly aroused that favorable action is imminent on this question. Under present conditions, a boiler must be constructed according to the province or city in which it is to be used, and manufacturers cannot very well build boilers for stock. As is the case in the United States, there are one or two satisfactory sets of laws in force in the Dominion.

BOILER CHECK VALVES AND FEED-WATER DELIVERY PIPES.*

The subject of check valves and feed-water delivery seems to be one to which very little thought has been given by the majority of the mechanical people; the established custom of placing the check valve on the side of the boiler, close to the flue sheet and below the waterline, being accepted as the proper location. This holds true with most all mechanical people we have referred to, they accepting the fact that there will be more or less precipitation and scale deposit, anyway, with the different kinds of water, and that checks should be placed at the coolest part of the boiler, thereby getting a better circulation and leaving such scale deposits as may be formed as far away from the fire-box as possible. However, we have information from mechanical people who claim they have made tests of the checks above the waterline, and that the results were most satisfactory. They contend that by placing the checks above the waterline, they have materially decreased flue failures. Mr. C. W. Seddon, superintendent of motive power of the Duluth, Missabe & Northern Railway, contends that on his road they had a number of engines, new from the locomotive works, that they were unable to get over the road satisfactorily, due to the engines not steaming and having considerable trouble with flues; also, that they were unable to keep certain classes of engines away from the shops on account of flues failing; and that after placing the check above the waterline the flue failures stopped, and he was able to keep his engines away from the shop, getting them over the road satisfactorily from every standpoint.

The following is a brief from Mr. Seddon, explaining his check:

By the Seddon boiler-feed device the feed-water is discharged from a perforated copper pipe in a spray, which, absorbing heat from the steam space of the boiler, strikes the surface at the temperature of boiling water. The result is to produce better circulation; eliminate leakage of tubes and locomotive failures resulting from the same; lost time and expense in the roundhouse incidental to calking of tubes and fire-box seams; overcome the breakage of stay-bolts, due to fluctuating temperature of water, and, further, to effect a visible saving of fuel.

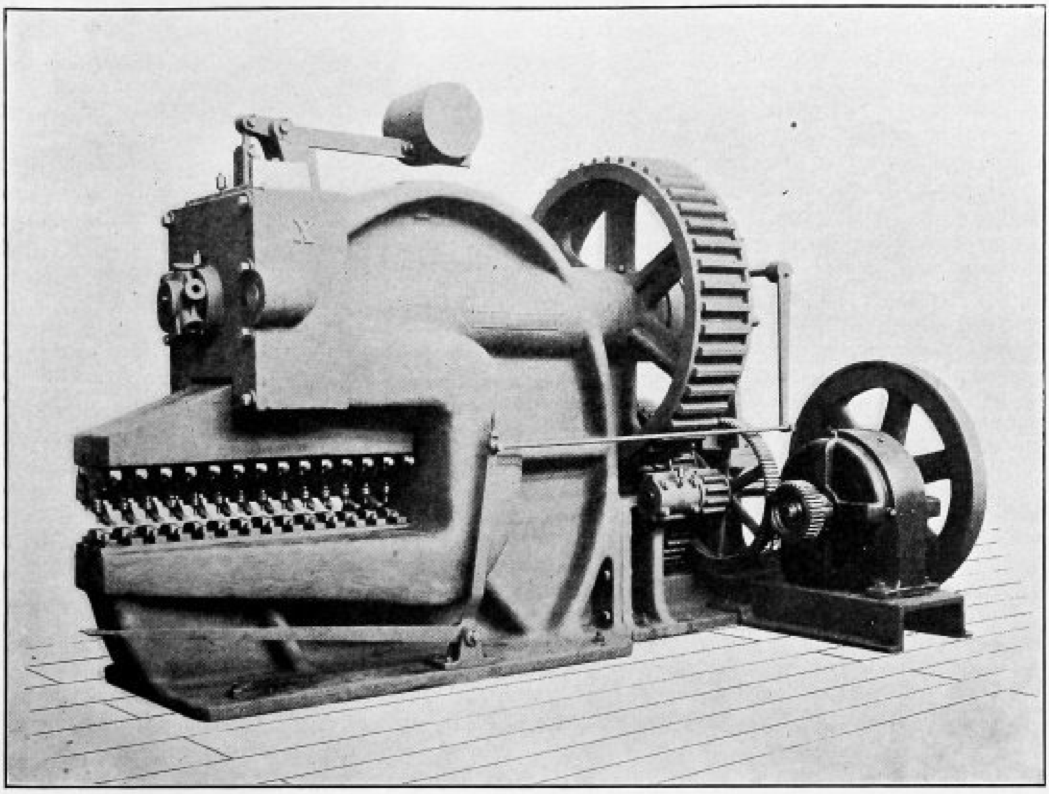
These statements are not theoretical, but rather are the result of long, practical and exhaustive tests on lines where the conditions are very severe. After being in service for two years, and to-day being applied to all their power, the records on one line show the following very remarkable results:

1. No boiler failures chargeable to leaky tubes.
2. 75 percent less work for boiler makers in the roundhouse on running repairs.
3. An increase in train tonnage of 10 percent.
4. A saving of fuel of 10 percent.

There can be no question but what if the check is located on top of the boiler, or above the waterline, we at least do away with the sticking of checks, and to a great extent do away with the grinding of checks. Your chairman has had considerable experience with Philips checks and cannot recall a single failure or check being destroyed from grinding. However, since the subject came up, your chairman has had to apply a great many flues to different classes and sizes of boilers, and, considering the length of time that flues were in the boiler, could see no noticeable difference with the checks in different locations.

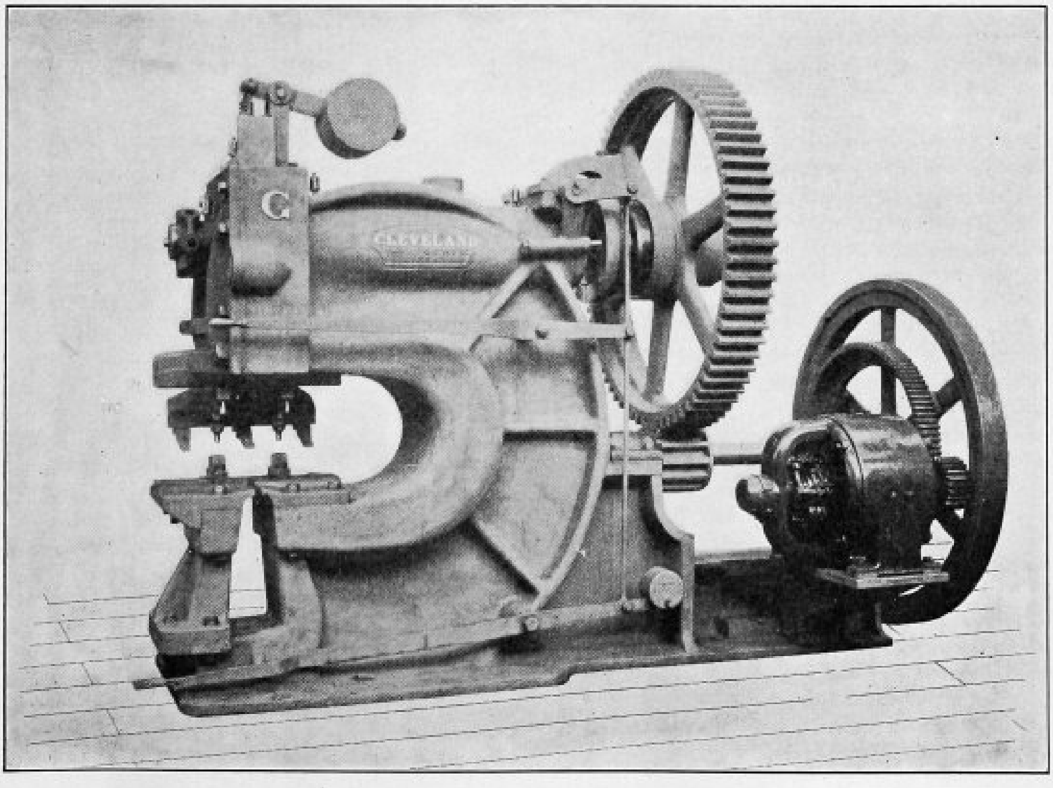
If what Mr. Seddon and Mr. Philips state about their checks holds true, it is worthy of further consideration, and,

* Read before the Traveling Engineers' Association, Sept. 7, 1909.



HEAVY MULTIPLE PUNCH EQUIPPED WITH 25-HORSEPOWER INDIVIDUAL MOTOR DRIVE.

a thorough test, as compared with other checks located on the side of the boiler, shall be made. Both of these gentlemen's claims for their check are very interesting, but, in our opinion, unless a test is made to convince the mechanical people that the general practice of placing the check valve on the side of the boiler is wrong, the established custom of



ONE FORM OF ELECTRIC DRIVE APPLIED TO A BEAM PUNCH.

so doing will still remain as right. We do not think, however, that the subject should be passed by without going into the matter more thoroughly. Practically all of the devices pertaining to the locomotive have been improved, and we cannot say without testing the matter but what a different location of the check and the water being deposited above the waterline would be better than below the waterline. Most likely this test could be brought about by our representatives to the Master Mechanics' Convention, who, in our opinion, are the proper people to have this test made.

As to the steaming of engine and working of injector, your committee fully agrees with all the mechanical advice it has that there is no noticeable difference in any location that should be made; however, the checks and injectors should be placed so as to allow slow, easy bends in the branch pipe.

The following is from the personal experience of your chairman: With the operation of the checks above the waterline, the committee would recommend that all checks be placed as far from the throttle-box as possible, due to the fact that with a check above the waterline close to the throttle-box, the throttle siphons the water very noticeably when the injector is working, which is bad on the valves and packing. We have, however, handled engines with the checks located on top of boiler and on front sheet next to smoke-box and noticed no bad results whatever along this line when the injectors were working. We would also suggest that no iron pipes be used with such location of checks, due to the fact that the bend that is necessary to be made to the check on top of boiler makes it next to impossible to keep the joints tight, due to expansion.

The following remarks are concerning the application and practices that should be followed in applying feed pipes, check valves, etc.:

The free and unrestricted passage of the water from the tank to the injector of a locomotive is of the utmost importance, and to attain this object it is necessary that all auxiliaries in connection with the water-feeding apparatus should be of proper construction, location and size.

One of the most important parts of the water-feeding system is the boiler check valve, and, in connection with it, the feed-water delivery pipe.

The pipe should be as short as circumstances and a well-established practice allow, and as straight as possible. In locomotive practice, the feed-water delivery pipes are usually bent, but these bends should not contain sharp elbows, but should be made in easy curves, so as to avoid abrupt changes in the current of the water and resulting frictional resistance, which may affect the general performance of the injector. For the same reason the pipe should be of proper size and free of obstructions of any kind, as obstructions in the delivery pipes will create a back pressure against the injector, which may not only affect its general efficiency, but may cause the water to be thrown out through the overflow, resulting in considerable waste of water if the injector is provided with an open overflow; or, in case of a closed overflow, injector obstructions may cause the injector to fly off, with the result that live steam will blow back into the tank, eventually heating the water to an extent that will make it difficult to again start the injector until opportunity is found to cool off the water.

As to the size of the delivery pipe, it is safe practice to follow the recommendations of the manufacturers of injectors and to make the pipe of the size called for by the connections at the delivery end of the injector.

Concerning the boiler check the first requisite is that it should be of ample size. In their connection the size of the pipe connections provided for the injectors by their makers give a safe connection.

All passages in the boiler check should be of the full size called for by these connections.

The check valve should have a sufficient lift as to avoid crowding and stowing of the water, which should result in back pressure and may be followed by consequences as related above. A lift of one-quarter to one-third of the clear opening covered by the check valve will be found serviceable, provided the clear opening is of the proper size. Preferably the boiler check should be of the "straight" type; that is, the water from the delivery pipe should enter the check body underneath the check valve, passing through it in a straight line, so as to avoid "turns" in the direction of the flow of water as much as possible.

The boiler check should be provided with a removable seat, as thereby the body of the valve is made practically indestructible, and in case the seat gets worn out, only the seat is to be replaced. The check valve itself and its seat should be accessible for inspection and regrinding or reseating—with pressure in the boiler. For this purpose, the boiler check should be provided with a stop valve; that is, a valve which, when shut, cuts off communication between the boiler and the check chamber, permitting the opening of the check chamber by removing the caps usually provided for this purpose. In case of double boiler checks, the two check chambers should be independent and separate from each other, and each chamber should be provided with its own stop valve, so that in case one side should become inoperative from any reason it could be cut off without interfering with the proper operation of the other side.

The stop valve should preferably be placed in a valve chamber of its own, independent of the check chamber, so that the stop valve could not possibly interfere with the proper operation of the check valve or prevent access to the check valve. If the stop valve is located in a chamber common to it and the check valve, the latter is not accessible, except after removal of the stop valve or after disconnecting the pipe attached to the boiler check, either of which necessities nullify the true purpose and usefulness of a stop valve.

THE MODERN LOCOMOTIVE BOILER.*

BY JOHN W. HOBSON.

JOINTS AND RIVETING.

The joints in a locomotive boiler should receive great consideration, because they are subjected to severe stresses as well as to a continual vibration. In this country, as a rule, the longitudinal joints, throat plate joints and smoke-box barrel ring are double riveted, the remainder being single riveted. The longitudinal joints should be well out of the water, to avoid corrosion. Of course, in the case of small boilers this is sometimes impossible on one ring; then it is better to have the joint totally submerged. The longitudinal joints should always be butt-jointed with double straps, as, if they are lap-jointed, grooving is almost sure to set in along the edge of the inner lap. This grooving is caused partly by the mechanical motion of the joint as the plate tends to pull into a straight line and partly by the chemical action of the feed water. The longitudinal lap-joint has led to more explosions than any other cause.

There is still a good deal of difference of opinion as to whether the rivet holes should be punched or drilled. It is now more common for them to be drilled, and there is very little difference in cost, because a punched plate must be annealed after punching, and it requires more handling to get

* Continued from the October issue.

a good joint. Both methods, however, possess advantages. The holes formed by punching are tapered and naturally the rivets hold more tightly in them than in drilled holes. On the other hand, drilled holes are drilled with the plates in place, whereas with punched holes drifting has nearly always to be resorted to, which is detrimental. Drilled holes should be slightly countersunk.

The riveting is done as much as possible by hydraulic power. Hydraulic riveting is much more perfect than hand; because the pressure comes on the whole body of the rivet, causing it to fill the hole exactly before forming a head. Also, with machine riveting, the head is always central with the rivet and calking is practically dispensed with.

When riveting by machine the pressure on the rivet should be from 55 to 65 tons per square inch of rivet, and care should be taken to heat them to a temperature of about 1,500 degrees Fahrenheit. The pressure on the head should cease while it is still red.

Before riveting a joint, care should be taken to have the plates tight together and no dirt between them, otherwise shoulders will be formed between the plates. A good way is to clean steel plates with a solution of sal-ammoniac and water, as this removes all scale, and ensures a good contact between the plates. I understand the Admiralty recommend a weak solution of hydrochloric acid, and I am inclined to consider this practice better, as the action of hydrochloric acid on steel is known, but it is not known as to whether sal-ammoniac has a permanent effect or otherwise.

If the plates are chamfered and well riveted by machine, they seldom require calking, as fullering is quite sufficient. Calking and fullering is done by pneumatic power.

Sketch A, Fig. 5, shows the usual form of longitudinal joint used in this country, the efficiency of which is generally about 72 to 75 percent. Sketch B, Fig. 5, shows a joint used to a small extent on the Continent. In this joint the horizontal seams are connected by sextuple riveted butt joints, and it will be noticed that the edges of the inner strap are corrugated between the rivets. This is a scientific method, no doubt, as the inner strap will be held with uniform firmness against the shell plate, and adds to the efficiency of calking, but it is a refinement not attempted in this country or America.

With steel boilers steel rivets should be used. These rivets are generally made from bars having tensile strength of from 26 to 30 tons, with an elongation of 25 percent in a length not less than eight times the diameter of the bars. The rivets in the fire-box are generally Yorkshire iron or steel, though some engineers will have nothing but copper for copper fire-boxes. Yorkshire iron are, in my opinion, the most satisfactory.

The rivet tests consist of bending the shank double while cold, and hammering the head until flat while hot, and there should be no sign of fracture or cracking.

FOUNDATION RINGS.

The foundation ring (called in America the mud ring) forming the bottom of the water space and connecting the inner and the outer fire-boxes is usually a mild steel or Y.I. forging, but sometimes a steel casting. The foundation ring joint is often a very troublesome one, and the setting of the plates at the corners requires to be very exact to make sure of a good job. The radii of the corners should not be too sharp, or it becomes extremely difficult to get rivets through or tap bolts in. The rings are most commonly single-riveted, although on large boilers double-riveted are preferable. Sometimes a compromise is made by making the corners double and between the corners single-riveted. Sketch A, Fig. 6, shows a single-riveted ring and sketch B a double-riveted one. The foundation rings generally give a water space of from 2½ to 3¼ inches.

TUBES.

The tendency nowadays appears to be to get as many tubes crowded into a boiler as possible, and thereby causing endless trouble through the spaces between the tubes themselves, and between the barrel and tubes becoming choked with scale; also the tube holes are too close together, and too close to the flange of the tube plate, thus causing cracks. The water spaces between the tubes should be a minimum of ⅝ inch, but ¾ inch is better. The Indian Standards Committee recommend ¾ inch. A good way is to have the water spaces at the fire-box and where evaporation is rapid ¾ inch and ⅝ inch at the smoke-box end. The most common arrangement of tubes is that shown in Fig. 1, they being placed in vertical rows. This method gives better circulation and allows sediment to fall down to the barrel. Frequently they are arranged in horizontal rows, as shown in Fig. 2. As a rule, more can be got in by employing this method, and should the tube top be dirty the flushing water has a better chance of dislodging it, as in the first instance the water has a tendency to pass straight down between the tubes.

Some engineers claim that the steam can escape more easily when the horizontal arrangement is employed, but I fail to see this, as its path is so very tortuous.

The tubes vary in diameter from 1⅝ to 2⅛ inches external diameter, and, of course, the smaller they are the more heating surface can be obtained. The practical limit to the smallness of a tube depends upon the possibility of keeping it from becoming choked. With respect to the tube itself, it is very effective near the fire-box, but its effectiveness rapidly decreases towards the smoke-box. As previously stated, the most efficient length of tube is considered to be about eighty times the outside diameter; if longer the increase of heating surface does not compensate for the diminution of draft.

In this country tubes are made of a variety of metals, but in America they are generally iron, though sometimes steel. Copper was the earliest metal employed and for express work is most satisfactory in every respect. Copper tubes are very ductile and do not therefore set up such severe expansion strains; they keep tight and last well. They should be just soft enough to stand expanding without the ends splitting, as if they are too soft they are likely to become badly scored by particles of unconsumed fuel, especially if the blast is at all severe. They are, however, very expensive.

Brass tubes are now most common in this country and on the Continent. The Indian Standards Committee recommend brass tubes, and seeing that they are principally used it would be as well to quote the British standard specification with respect to their composition and the test they have to undergo.

Their composition is to be either 70/30 or 2/1 alloy. With the 70/30 mixture there should not be less than 70 percent metallic copper, and not more than .75 percent of materials other than copper and zinc. With the 2/1 alloy there should not be less than 66.7 percent of metallic copper and not more than .75 percent of materials other than copper and zinc. They must also stand severe bulging, flanging, flattening and doubling over tests, as well as an internal hydraulic pressure of at least 750 pounds per square inch.

Red metal tubes, being somewhat intermediate between brass and copper, appear to have excellent qualities. Muntz metal tubes have also been tried, but not adopted to any extent. The high price of copper and its alloys, however, makes it necessary to look around for a substitute. Now experiments and practice show that there is really very little difference in the evaporative powers of copper, brass, steel or iron tubes, after a few weeks' work with impure water. Of course, the more expensive metals last much longer, and after use their scrap value is a big consideration, whereas steel tubes, for instance, only last four years and their scrap value is practically *nil*.

Mild steel tubes, both hot and cold solid drawn, are finding a little favor at present in this country, but they deteriorate very rapidly with certain classes of feed water, though with certain other classes of feed water they last longer than brass, so that it appears to be a question of local conditions, viz., quality of feed water and fuel used. There is also a difficulty in keeping them tight in the tube plates, and incrustations adhere more firmly to steel tubes than to copper or brass.

With respect to Serve tubes, I may say that although considered a great success in France, yet the Midland Railway Company have discarded the ones they had on trial. They are very expensive, and there is a great difficulty in keeping them clean. As will be seen from sketch D, Fig. 14, the Serve tubes have internal ribs; these increase the surface in contact with the gases by about 90 percent. The object of these ribs is, of course, to slice and take the heat more effectually from the gases.

Several railway companies are at present giving Mr. Drummond's fire-box water tubes a trial, the North Eastern Railway being one of them. These tubes are as a rule 2 or 2⅛ inches diameter, and to use them effectually a very deep fire-box is required. As they are directly exposed to the flame, the temperature of the water in them must be raised very quickly, and I should think they will aid circulation. They are expensive to fit and there is trouble in gaining access to them. Brass or copper tubes are usually 11 or 12 S. W. G. thick at the fire-box end, and taper to 13 or 14 S. W. G. at the smoke-box end. They are generally fixed in the tube plates as shown on sketch A, Fig. 14, viz., expanded at both ends, beaded over and ferruled at fire-box end only.

Sometimes they are swaged down to an ⅛ inch less diameter at the fire-box end, as shown at sketch B (Fig. 14). This is a good plan, as it allows for repeated expandings without making the holes in the tube plates too large. The ferrules are of steel or malleable, and about 1¼ or 1½ inches long. They are intended to protect the tube ends from the fire. Iron and steel tubes are generally the same thickness throughout, and sometimes pieced with copper or brass ends about 6 inches long in order to get over the difficulty of making them tight in the copper tube plate. This, however, is not quite satisfactory, a much better way being to swage them down, as shown at sketch B, Fig. 14, expand them and bead them over, ferrules being dispensed with.

In America, where they have the steel fire-box to deal with, it is customary to have a copper sleeve between the tube and the tube plate with which to make a joint. Ferrules are never used in America; sketch C, Fig. 14, shows this method.

Tubes should have a camber of at least 2 inches and hang down over in order to relieve the stresses due to expansion and contraction and also to the floating tendency. A good idea is to bead several tubes over at the smoke-box end, which then act as stay tubes.

THE INSIDE FIRE-BOX AND STAYING OF THE SAME.

The internal fire-box is almost invariably made of copper in this country and on the Continent, though in America it is always of steel. A copper box certainly wears better than iron or steel and it should have a higher evaporative efficiency, as copper is a much better conductor of heat than iron or steel, the ratio being something like 74 to 12. It has also the advantage of being better able to resist oxidization and corrosion. It can be worked with great ease, as it is so very ductile and malleable and will stand a great deal of straining action. It has homogeneity of texture, is free from blisters and laminations, is capable of resisting sudden and repeated strains and combats well the wasting action of a fierce fire. It also resists the tenacious adhesion of most kinds of scale. Copper, however, has two disadvantages, viz., its strength decreases rapidly with an increase of temperature. At 32 degrees Fahrenheit its tensile strength is on an average 15 tons per square inch, whereas at 850 degrees it is reduced to about 7.5 tons. Copper is an exorbitant price, but I think its high scrap value and greater lease of life justifies locomotive engineers in this country and the Continent in retaining its use for fire-boxes.

The British Standards Committee recommend that copper plates for fire-boxes be of two qualities to meet the largely varying chemical constituents of coal and other working conditions of use:

(1) That plates must contain not less than 99 percent copper and from .35 percent to .55 percent of arsenic.

(2) That they must contain not less than 99.25 percent copper and from .25 to .45 percent arsenic.

They should show a tensile strength of not less than 14 tons per square inch with an elongation of not less than 35 percent on 8 inches. Also that pieces of the plate should be tested both cold and at a red heat by being doubled over on themselves—that is, bent through an angle of 180 degrees without showing either crack or flaw on the outside of the bend.

The thickness of the fire-box plates varies from 7/16 inch with 150 pounds working pressure to about ⅝ inch with 220 pounds working pressure, the pitch of the stays being seldom more than 4 inches, the part of the tube plate taking the tubes being about ¾ inch thick with 150 pounds pressure to 1 1/16 inches with 220 pounds. These thicknesses, of course, allow a large margin for wear; in fact, the plates may be allowed to wear down to half their original thickness, providing the stays still retain good heads.

Lowmoor iron boxes have been tried but not adopted to any extent, although I may say a local colliery company is using them with great success. As mentioned before, American fire-boxes are always of steel, their great argument in favor of it being that by employing the same material for inner and outer box the galvanic action and consequently corrosion of the plates is hindered; also the difference in expansion between the inner and outer box is minimized. They also say that the thinness of the plates there in use compensates for any difference between steel and copper as conductors of heat. The Americans have experimented a great deal and definitely decided on steel for fire-boxes; but, strange to say, experiments carried out here and on the Continent have proved unfavorable to steel and its use has been abandoned. Either the experimenters here used plates too thick or inferior in quality to the plates used by the Americans, or otherwise the Americans are satisfied with a short-lived fire-box. English engineers, however, do not believe in constant renewals.

It is a good way to make the fire-box roof concave when the round top fire-box is used, as it suits the staying better, and is better able to receive and transmit heat and to boil off sediment. With the flat-top box the corners of the inside box should have a large radius to permit flexibility. The sides of the fire-box are stayed by screwed stays about 4 inches pitch. With a copper box it is, of course, necessary to use either copper or copper alloy stays, to avoid corrosion by galvanic action, which frequently occurs near the fire-box plate. Many engineers make the mistake of having these stays too close to the flanges and on the curves of the wrapper plate. The result is that the flexibility of the box is diminished, causing cracked plates and broken stays. Sketch A, Fig. 15, shows the common form of copper stays. It is screwed through both plates and riveted over. The head on the inside should be very large to resist the action of the fire, but the head on the outside only requires to be large enough to make a tight job. Care should be taken that these stays are not screwed in too tightly, as there is a danger of an initial torsional strain being set up which would prove detrimental to their life. The diameter of these stays depends upon the working pressure and they generally have a stress on them of from 4,000 to

5,000 pounds. I think, however, a stress of 3,500 is better, as it allows the fire-box plate to wear down a great deal before there is any danger of collapse. Sketch B, Fig. 15, shows a modification of the former. This has the thread turned off in the center, which is supposed to give flexibility.

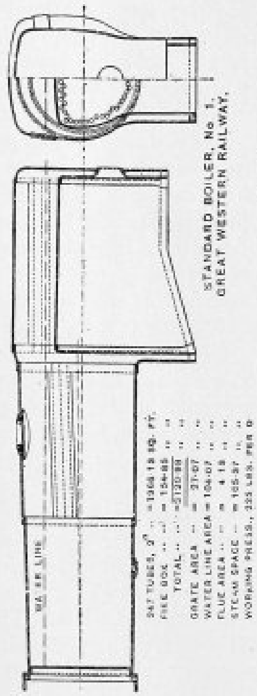


FIG. 3.

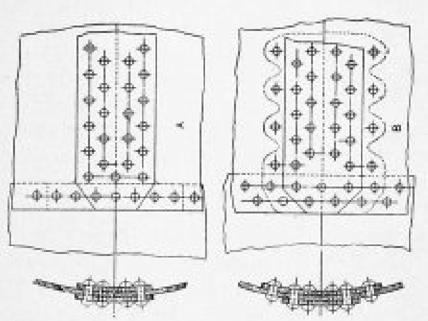


FIG. 5.

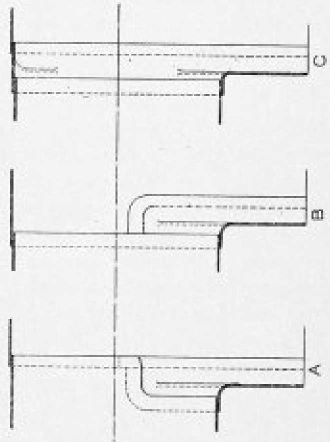


FIG. 4.

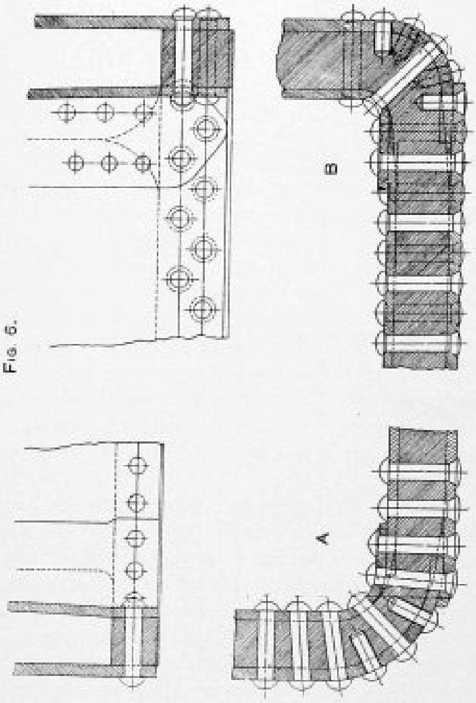


FIG. 6.

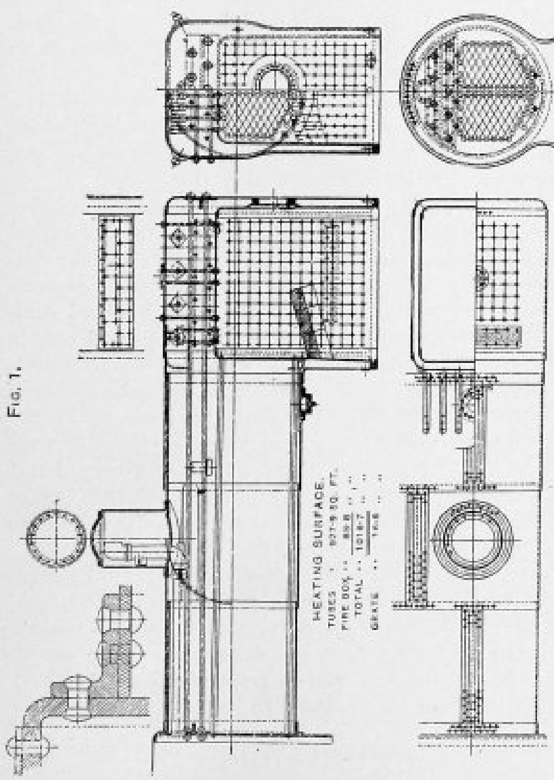


FIG. 1.

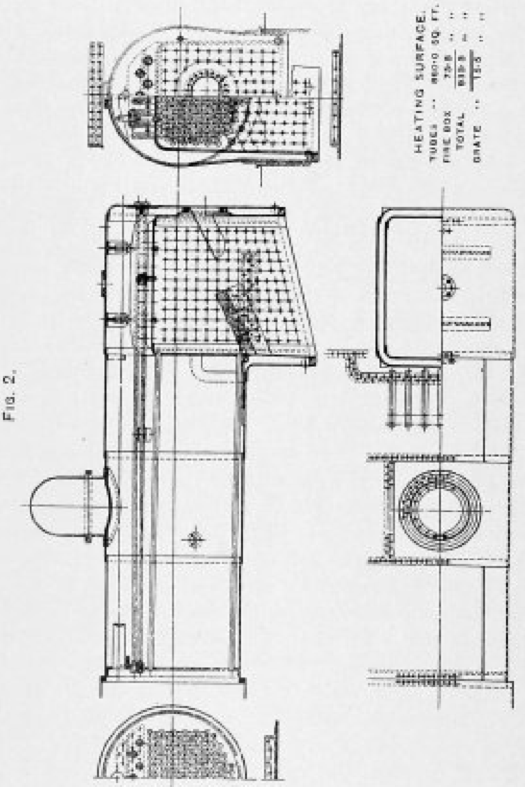


FIG. 2.

The gain in flexibility, I feel sure, will be so slight that it is not worth the expense of turning the thread off and the trouble caused during renewals when sorting the stays, as, of course, their length varies. It will be noticed that there is a small hole, generally ⅛ inch diameter, drilled up the center of the stay. The object of this is to give warning when the stay breaks by blowing into the fire-box. This is not often done in this country, though very frequently on the Continent. It is an unnecessary refinement, as a broken stay can be so readily detected. Sketch C (Fig. 15) shows a form of stay manufactured by John Stone & Company which is truly a flexible stay. The flexibility is obtained by sawcuts at right angles to one another and is gained at only a very slight loss in tensile strength.

The stay shown at sketch D, Fig. 15, known as Park's stay, dispenses with the necessity of riveting. It is screwed into the plates and then tightened in them by the driving of a conical drift into the holes shown in sketch. This is more suitable for iron or steel fire-boxes, but it is not much used now. With iron or steel fire-boxes Lowmoor stays are used, usually about 6 inches pitch and of the form A or B, Fig. 15.

With respect to phosphor bronze stays, the objection to them seems to be that with some kinds of coal the heads rapidly waste away in a somewhat peculiar manner. The cause of this is not known, but it is certainly worth investigating.

The top of the fire-box being either flat, at any rate only slightly curved, requires staying. Girder stays of wrought iron, as shown in Fig. 2, were formerly used, these being attached by slings to the outer shell. As the size of fire-boxes increased and it became necessary to use higher working pressures, this form of stay became cumbersome and cast steel girders, Fig. 13, were then adopted as the best main-line practice. These in turn became large and clumsy. The fire-box plates were attached to the girders by means of tap bolts, as shown, or sometimes by through blots, but were, until quite recently, used almost universally by main-line engineers. Direct stays have now, to a great extent, taken their place, and rightly so.

The private builders generally in this country and most of American engineers appreciated the superiority of direct over girder stays at least thirty years ago. Girder stays obstructed the circulation and became choked up with deposits from the feed water, causing the crown plate to become overheated. Some engineers thought that there was more freedom of expansion with girder stays, and refrained from staying the inner box directly to the outer shell on account of the great strain caused by the greater upward expansion of the inner box, but this objection is entirely removed in the Belpaire fire-box, which has its outer casing flat with well-rounded corners, as shown in Fig. 1. This type gives great satisfaction. The first two rows of stays allow for the upward expansion over the tube plate and will, at the same time, resist collapsing. It is very necessary to make allowance for this expansion, as when the fire is first lighted the tube plate is heated first and, of course, expands first, otherwise cracks will develop along the root of the flange of the tube plate and also tend to make the tubes leak. Fig. 1 shows a well-designed Belpaire fire-box.

Direct stays are not quite such a success in round top boxes as in the Belpaire, but still they are preferable to girder stays. Direct stays are generally pitched 4¼ by 4½ and stressed as a rule to between 5,000 and 6,000 pounds per square inch, although 9,000 is allowed for steel and 7,000 for iron stays.

Another method of staying the fire-box roof which deserves mention is that adopted by the Great Western Railway Company, as shown on Fig. 12. In this case the stays are arranged in groups of eight, which are screwed into small castings and have ferrules on the bolts. Each casting is slung independently from a bracket on the outer casing, the holes in the sling links being oval to allow for upward expansion. When well fitted this form gives great satisfaction, but care has to be taken to get the slings loaded uniformly or the roof will become distorted. I am dwelling on this question of staying at great length, but really it is of the utmost importance, as fire-box stay troubles are innumerable. Referring to Fig. 9 we see before us at sketch A the most common form of direct expansion stay, and at sketch B the direct stay. Observe the knife-edged nut which makes the joint with the copper plate. With steel or Y. I. plates it is usual to make the joint with copper washers. The direct stays are screwed through both the inner and outer plates. With the round top box the stays do not have nuts on the outside, but the ends are riveted over. In Fig. 11 it will be noticed that the direct stays are protected from the water by iron piping and cement. Fig. 10 shows the form of expansion stay used with great success by several leading railway companies in this country. It is the method recommended by the Indian Standards Committee.

Referring once more to Fig. 9, we find at sketch C a stay known as a palm stay, the object of which is to support the tube plate just below the tubes. There is generally a big space between the top row of fire-box stays and the bottom row of tubes. I think these stays could be dispensed with, as it is often found that when a boiler comes in for repairs after long service these are broken, and they certainly impede circulation where it is most needed.

It would be a simple matter to continue the thickened part of the tube plate down to the top row of stays. If palm stays are to be used, they should be at any rate 2 feet 6 inches long. The palm stay is connected to the tube plate by a screwed copper stay, riveted over on the inside of the box. There should be a space between the palm stay and the plate, giving a length of copper stay. This, together with the length of stay before mentioned, should give ample flexibility.

BOILER STAYS.

Sketch D, Fig. 9, shows a transverse stay. These stays are for staying the flat sides of the Belpaire box and are arranged as shown in Fig. 1. Sketch E, Fig. 9, shows a longitudinal stay. These are for staying the smoke-box tube plate and the fire-box back plate together above the tubes. They are screwed into the back plate and passed through the tube plate, the joints being made with copper washers. Sometimes these stays have a coupling in the middle.

Instead of through stays, diagonal stays, as shown in Fig. 11, are often fitted. These have double eyes at each end, which take stiffening angles on the back and tube plates at one end, and a bracket on the barrel plate at the other.

With the coned boiler the method usually adopted consists in fastening, by means of tie-rods similar to these diagonal stays, the front tube plate to the first barrel plate and the fire-box back plate to the coned portion of the barrel. Formerly gusset plates only were used, but I think the Midland Railway Company is the only company who have fitted any in recent years in this country, that is, with high-working pressures, although on the Continent, as a rule, the tube and back plates are merely stiffened with angle or tee irons.

Some engineers also provide stay tubes or through stays between the tube plates for high-working pressures, but I think this unnecessary, as the area exposed to pressure is very small and the tube plates are so thick. It is quite enough to bead over several tubes at both ends.

The direct, longitudinal and palm stays are generally made from steel bars though sometimes Y. I. is used. The usual working stress of direct stays is from 5,000 to 6,000 pounds, and of longitudinal stays 8,000 to 9,000 pounds; 9,000 pounds is allowed in both cases for steel stays and 7,000 for Y. I. stays which have not been welded or worked in the fire.

EXPANSION ANGLES.

Expansion angles and brackets for supporting the boiler on the frame at the fire-box end and allowing at the same time for expansion, are usually fitted. The boiler is a fixture at the smoke-box end, and as the expansion is about ⅝ inch be-

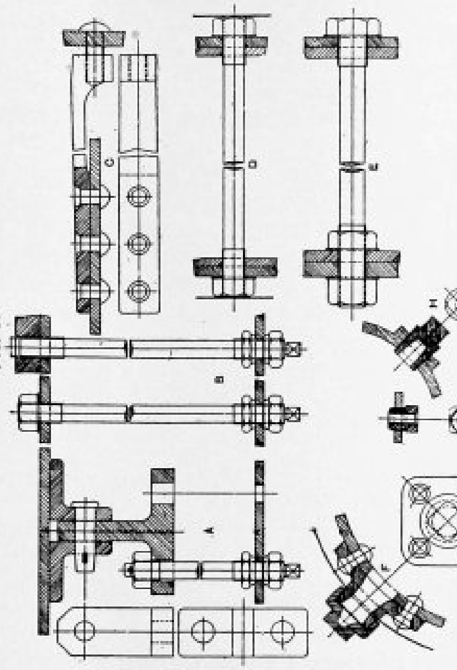


Fig. 9.

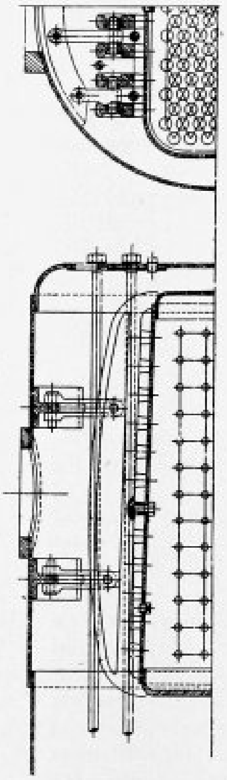


Fig. 13.

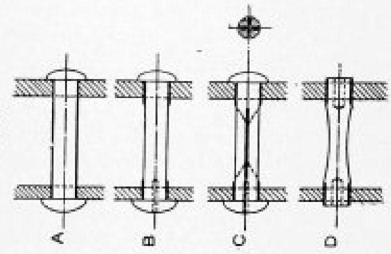


Fig. 15.

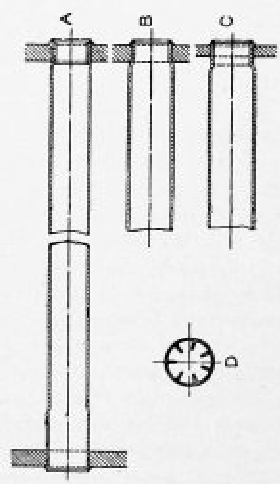


Fig. 14.

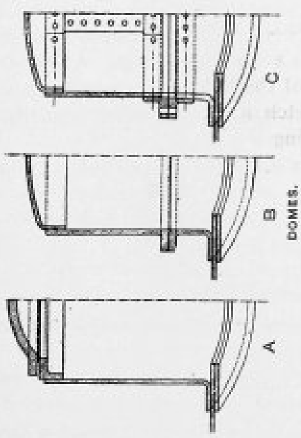


Fig. 8. DOMES.

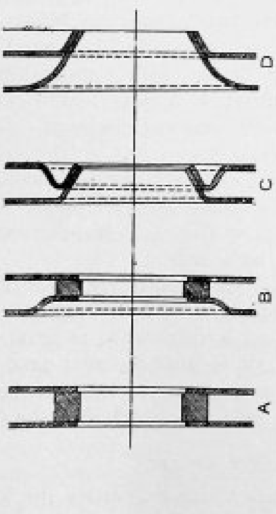


Fig. 7.

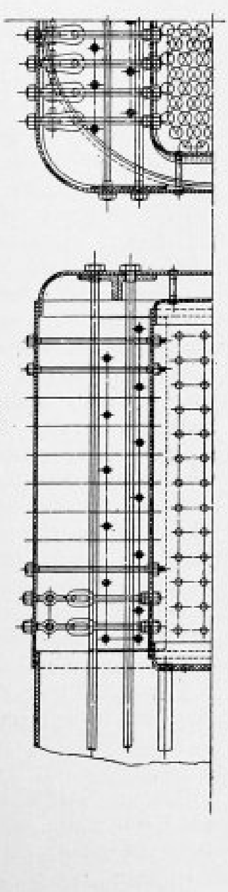


Fig. 10.

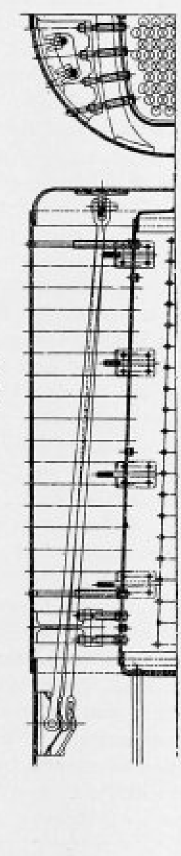


Fig. 11.

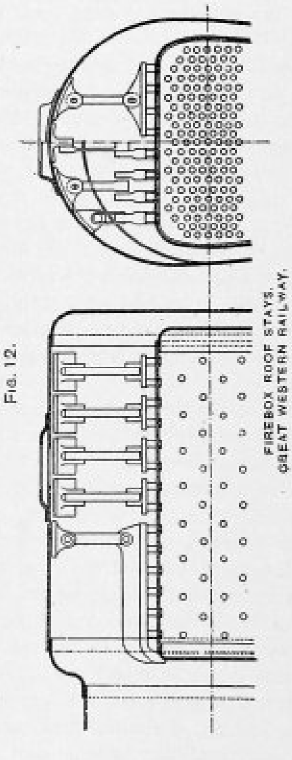


Fig. 12. FIREBOX ROOF STAYS. GREAT WESTERN RAILWAY.

tween hot and cold, some such arrangement is necessary. Clips are provided which prevent the boiler rising and generally a pin and socket controls the movement laterally when running. Fig. 2 shows the expansion angles.

WASHING-OUT FACILITIES.

As will be seen from Figs. 1 and 2, the locomotive boiler is elaborately provided with mud holes, etc., which is, of course, most necessary. Sketch F, Fig. 9, shows the seatings and caps placed on the radii of the fire-box. Sketch H, Fig. 9, shows a mud plug, always tapered, screwed about 12 threads to the inch, and made of brass. Sketch G, Fig. 9, shows a fusible plug. It is customary to provide two of these in the crown of the fire-box. Should the water fall below the level of these the fusible metal melts and allows the steam to escape into the fire-box.

DOMES.

The question as to whether a dome is of use on a locomotive boiler is still very much discussed. Of course the primary object in view is to collect the steam as dry as possible. The regulator throttle is then placed as high as possible above the waterline, as the locomotive boiler is worked very hard and generally supplies very wet steam.

One of the points in favor of the dome is that it acts as a receptacle for the regulator and internal pipe ends and as a manhole. On the other hand, it is a source of weakness, and as a rule a manhole can be placed in a much more convenient position. Personally, I think the dome quite unnecessary on large boilers, especially when the Belpaire fire-box is used in conjunction with the coned barrel. On the Great Western Railway the engines without domes are as free from priming as any. When domes are not used a collecting pipe perforated on the upper surface is placed as high as possible in the barrel. It may interest you to know that Messrs. R. & W. Hawthorn were the originators and patentees of the domeless boiler in conjunction with what is known as Stirling's dry pipe.

Domes vary a great deal in design and construction. They are generally made from steel plate when the boiler is steel, though sometimes they are of Y. I. when they are welded. The type shown in Fig. 2 may be a steel casting or made from plate, the base being either a steel casting or made from an angle. The dome covers, as shown in Fig. 1 or sketch A, Fig. 8, may be again either a casting or plate. The vertical joint is generally welded, but with a high-working pressure I consider it safer to be riveted, having inner and outer butt straps. The strength of a riveted joint is known, but a welded joint depends entirely upon the skill of the workmen, and it is not easy to judge from appearance as to whether it is sound or not.

The dome should always be provided with a stiffening ring, as the barrel plate is much weakened where cut out to take the dome. When the dome is of the type B (Fig. 8) or as shown on Fig. 2, the regulator is conveniently accessible for repairs, but the joint is apt to become distorted owing to varying stresses set up in the barrel plate. This type of dome is very suitable when boilers are to be shipped abroad, as the total height is reduced, which means a great saving of shipping space. The domes shown in Fig. 1 and sketch A, Fig. 8, are more suitable for saddle-tank engines.* Dome joints are generally faced and made with boiled oil, but sometimes a copper jointing ring is used, as shown in sketch A, Fig. 8. The Americans generally make their dome joints with black lead, which makes a capital joint. This joint lasts well, and when opened up is as smooth as when first made.

* Sketch C, Fig. 8, illustrates the type recommended by the Indian Standards Committee. Its advantages are obvious, and it is fast becoming the favorite type.

FIRE HOLES.

Fire-hole joints are made in a great variety of ways. Sometimes a plain welded Y. I. or steel ring is placed between the inner and outer plates, as shown in sketch A, Fig. 7. This is invariably the method when the inner box is of steel or iron.

As a rule, in this country the fire-hole ring is thinned to 1¾ inches or 2 inches and the inner plates dished out to suit, as shown in sketch B, Fig. 7. This is better than the first mentioned, as it gives greater flexibility to the fire-box and the rivet heads are somewhat removed from the action of the fire. Sketches C and D, Fig. 7, show methods by which the rivets are still better protected, but scale forms in the angles and it is very difficult to dislodge.

BRICK ARCH.

There is almost invariably a fire-brick arch fitted in the fire-box, as shown in Figs. 1 and 2. This arch is placed just below the tubes and extends across the fire-box. Its objects are many. It keeps the temperature in the fire-box more equable, ensures more perfect combustion by diverting the flame and gases to the back of the box and prevents to a great extent small cinders being carried into the tubes. It protects the tube ends, as the flames are prevented from licking them, and it forms a large incandescent mass which radiates heat to the tube and roof plates.

DEFLECTOR AND PROTECTION PLATES.

A deflector plate is sometimes provided, as shown in Fig. 2. Its object is to deflect the cold air downward when the fire-door is opened. It is certainly a good plan to prevent cold air reaching the tube plate, as it is liable to cause a sudden contraction, which tends to make the tubes leak. As the deflector plate, however, obstructs radiation, many engineers are discarding it and having the fire-door opening inwards, which acts as a deflector.

A protection plate is usually fitted around the bottom of the fire-hole ring, as shown in Fig. 1. This protects the joint of the inner plate from the fireman's shovel and irons. Sometimes this takes the form of a casting.

CONCLUSION.

From the preceding you will have concluded that the locomotive boiler is an expensive item, and, with the high-working pressure required to-day, a very troublesome one. Although low-working pressures would prolong its life and reduce the cost of maintenance, modern requirements make it necessary to employ high pressures; but perhaps superheating may relieve the tube and stay trouble somewhat, as it affords the prospect of obtaining the same steam efficiency at a pressure of, say, 170 pounds, as is at present obtained from unsuperheated steam at about 200 pounds. Germany and Canada are giving superheaters a fair trial, and the Great Western have fitted one on the Schmidt principle.

Mr. Halpin's system of thermal storage aids rapid evaporation, but it is difficult to arrange on such a cramped machine as the locomotive. The Lancashire and Yorkshire Railway Company are giving this system a trial. This railway company are also trying the cylindrical corrugated fire-box with a view to alleviating stay trouble. These are, of course, simple to construct, and with them good circulation is obtained, but they do not appear to give satisfaction and the fuel consumption is higher. The London and North Western have also given this type of fire-box a trial, but seem to have abandoned the idea of further adoption. The Americans, however, have quite a number of these in service and are constructing more. They claim this type as their innovation under the name of Vanderbilt's fire-box, but R. & W. Hawthorn constructed both plain and corrugated as early as 1881 for service abroad.

In conclusion, I may say that any idea likely to cheapen the cost of production of the locomotive boiler, lessen its maintenance charges or increase its value as a steam generator, would be gladly welcomed by locomotive engineers throughout the world.

AN INEXPENSIVE FURNACE FRONT AND DOOR.

There are few accessories to the steam boiler that rank so high as the furnace doors when the matter of economy of fuel is concerned, and many and various are the patents connected with them. To write exhaustively concerning any one type of door might be comparatively easy were it not for the fact that the ideas connected with them are numberless, and it would be superfluous for me to attempt to describe what is unquestionably the "property" of every boilersmith, viz.: the general principle of an aperture with a movable part attached, which is brought into play every time the stoker tends his fire.

Any reference, then, made to the commonplace door is made apologetically. A simple, yet very effective, example of a door with mountings complete has come under our notice, and bids fair to enjoy a measure of popularity for marine or general use. It might be described as a semi-balance door, and has some advantages over the ordinary type of balance door. Its weight, or want of it, is the first thing that might be noticed, since the various parts composing the door, etc., are made from the lightest material. The absence of the excess of heat from a heaped-up fire, which frequently accompanies the indiscreet habit of allowing live coals to accumulate too near furnace front unnecessarily.

On the other hand, the horizontal inward position of the door while open serves to protect the rivets, etc., on top of furnace mouth from the inrush of cold air, which usually takes place more or less during firing operations, which excess inrush of cold air often has the effect of chilling the landing edges, and causing seams to leak. To avert this leakage certainly saves many a bill for boiler makers' calking and subsequent repairs.

A consideration at this point might be the advantage of the economical nature of its construction, as in the making of the frame and door many of the cuttings of angle bar and scrap plate might be utilized. The base of the frame is made

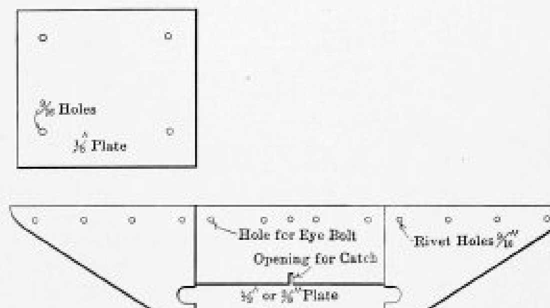
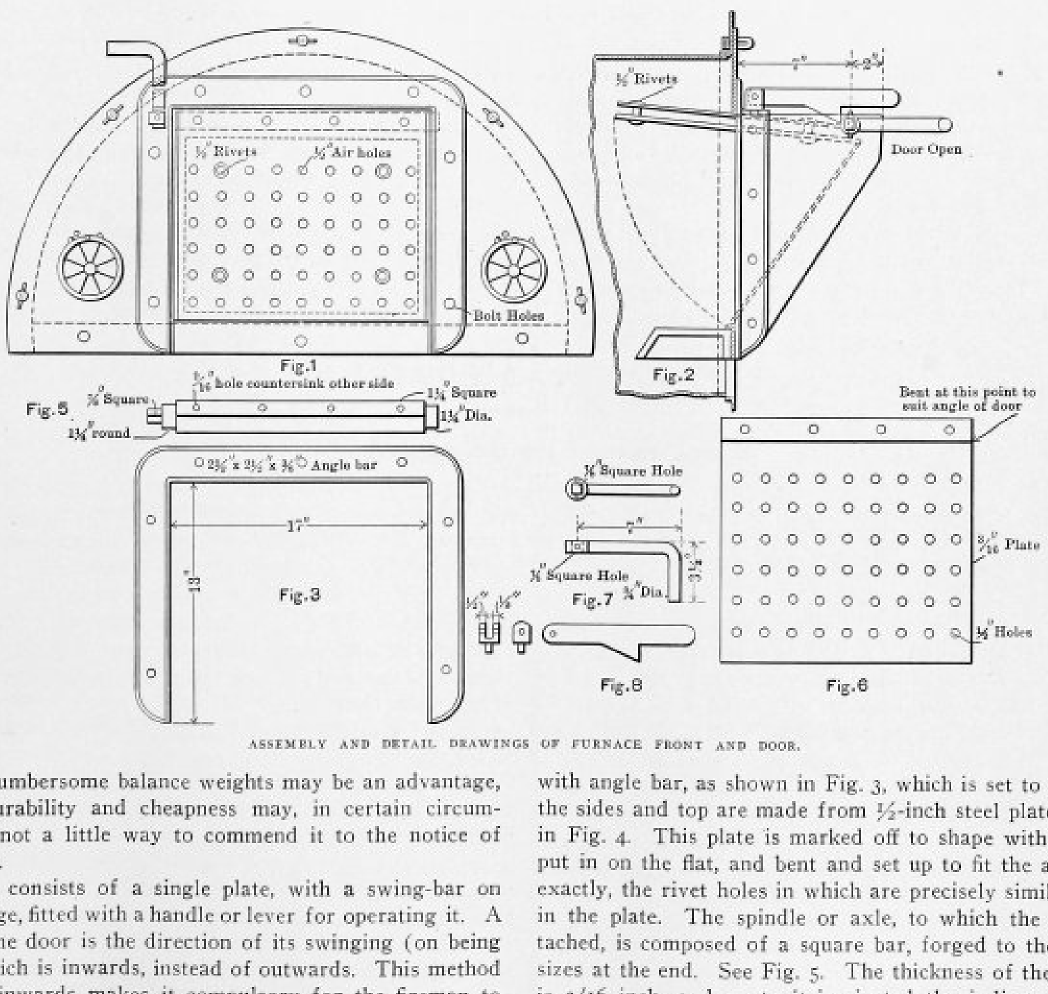


Fig. 4



ASSEMBLY AND DETAIL DRAWINGS OF FURNACE FRONT AND DOOR.

sometimes cumbersome balance weights may be an advantage, while its durability and cheapness may, in certain circumstances, go not a little way to commend it to the notice of steam users.

The door consists of a single plate, with a swing-bar on the upper edge, fitted with a handle or lever for operating it. A feature of the door is the direction of its swinging (on being opened), which is inwards, instead of outwards. This method of opening inwards makes it compulsory for the fireman to keep his fire well back from the dead plate, which action (perhaps unconsciously to the fireman) serves to protect the seam and rivets round the top of the furnace mouth from the

with angle bar, as shown in Fig. 3, which is set to gage, while the sides and top are made from ½-inch steel plate, as shown in Fig. 4. This plate is marked off to shape with every hole put in on the flat, and bent and set up to fit the angle frame exactly, the rivet holes in which are precisely similar to those in the plate. The spindle or axle, to which the door is attached, is composed of a square bar, forged to the particular sizes at the end. See Fig. 5. The thickness of the door plate is 3/16 inch, and on to it is riveted the indispensable baffle plate, ⅛ inch thick, with ferrules or distance pieces of, say, ¾ inch between, to provide an air space.

It is generally conceded that a certain amount of air must

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STATIONARY BOILER RECORD.

Location ____ Type ____ No. ____
Locomotive Class Removed from ____ Specification No. ____
Transferred or New ____ Builder ____ Jobber ____ Req'n No. ____
P. A. Order No. ____ Date Purchased ____ Date Built ____ Date Received ____
Date Installed ____ Cost ____ Terms ____

DESCRIPTION

Draft: Natural, Forced or Induced ____
Class of Fuel Designed for ____
Flues: Number ____ Diameter ____
Flues: Length ____
Flues: Gauge ____ Spacing ____
Firebox: Length ____ Width ____
Feed Water Heater: Type ____
Feed Water Heater: Dimensions ____
Grates for ____ Coal
Grate Area: ____ Sq. Ft.
Heating Surface: Flues ____ Sq. Ft.
Heating Surface: Firebox ____ Sq. Ft.
Heating Surface: Total ____ Sq. Ft.
Ratio of Grate Area to Heating Surface ____
Rated Horse Power ____
Smoke Box: Length ____ Diam ____ Width ____

Stack: Diameter ____ Height ____
Stack Connection: Size ____
Stack Breeching: Small Size ____ Large Size ____
Safe Working Pressure (Form 44-B) ____
Method of Firing ____
Mechanical Stokers. Type ____
Method of Boiler Feed: Injector or Pump ____
Ground Space Occupied ____
Superheater: Type ____
Superheater: Surface ____
Superheater: Total Dimensions ____
Degrees Superheat Leaving Boiler ____
Water Columns: Type ____
Gauge Cocks: No. ____ Distance from crown sheet to lowest
1st to 2nd ____ 3rd to 4th ____

MEADVILLE, PA., ____ 190__

FORM OF FILING STATIONARY BOILER RECORD USED ON THE ERIE RAILROAD.

be admitted above the grate, but it is difficult to determine just how much. With the assistance of a venetian ventilator, or gridiron, or other contrivance, the difficulty is brought to a minimum, and in the case of the door under our consideration, the door proper is perforated with holes of, say, ½ inch diameter. See Fig. 6.

A handle for opening the door is forged from ¾-inch round mild steel, with suitable end to take swing bar. See Fig. 7. A simple catch (Fig. 8) for keeping the door open during the firing operation is made from ⅜-inch plate, and fitted with an eye-bolt, or wrought eye attached through the angle bar and riveted over.

In the accompanying drawing, Figs. 1 and 2 show the completed door and frame in position, while the other sketches give an idea of the details in general.

While it is hoped that this method of constructing a door will prove of value to many of our readers, it is also hoped it will lead them to suggest other designs they have found satisfactory, as it is only by examining many ideas one can arrive at a correct estimate of the value of any one design.

[illegible]

ERIE RAILROAD COMPANY.

NEW YORK, SUSQUEHANNA & WESTERN RAILROAD. CHICAGO & ERIE RAILROAD. NEW JERSEY & NEW YORK RAILROAD.

STATIONARY ENGINE RECORD.

Location ____ Type ____ No. ____
Jobber ____ Builder ____ Transferred or New ____
Req'n No. ____ P. A. Order No. ____ Spec. No. ____ Cost ____ Terms ____
Date Purchased ____ Date Received ____ Date Installed ____

DESCRIPTION.

Bed: Length ____ Width ____
Belt Wheel: Diameter ____ Face ____
Balance Wheel: Diameter ____ Face ____
Cylinders, High Pressure: Diam. ____ Stroke ____
Cylinders, Low Pressure: Diam. ____ Stroke ____
Condensers: Type ____ Builder ____
Condensers: Surface ____
Dist. Centre of Engine to Centre of Pillow Block ____
Dist. Centre of Engine Shaft to Centre of Main Line Shaft or Jack Shaft ____
Exhaust: Diameter ____
Governor: Type ____ Size ____
Line Shaft Belt Pulley: Diam. ____ Face ____

Pillow Block: Size of Base ____
Packing, Piston Rod: Kind ____
Packing, Cylinder: Kind ____
Packing, Valve Rod: Kind ____
Piston Rod: Diameter ____
Valve Rod: Diameter ____
Engine Shaft: Diameter ____
Total Length ____ Rated Horse Power ____ lbs. Initial Pressure
Speed: ____ R. P. M.
Throttle: Type ____
Throttle: Diam. of Steam Inlet ____
Valve Gear ____
Valves: Type ____
Vacuum ____

MEADVILLE, PA., ____ 190__

STATIONARY ENGINE RECORD BLANK, ERIE RAILROAD.

EQUIPMENT RECORDS.

BY C. E. LESTER.

I have no doubt but that private concerns have a systematic method of filing shop equipment records; but, as a rule, railroad companies are rather lax in this respect. In fact, some roads with which I have been connected have no record whatever of stationary boilers, engines, etc., with the possible exception of a shop record of the installation of the apparatus filed away in some pigeonhole where it could never be found.

To the general machinery inspector, general foreman boiler maker, and any or all persons who are required to look after repairs and renewals and installation of new shop equipment, the importance of a clear and concise general office record of shop equipment cannot be too greatly appreciated.

It is generally the custom when a boiler, engine, air compressor, pump, etc., has outlived its usefulness on account of old age, faulty design or desired increase in output and efficiency for the shop or some outlying pump station, coaling plant, etc., for the person or persons who follow this work to go to the plant and spend a day or two inspecting and checking up dimensions on the apparatus to see what will be required to replace it with something that will "fill the bill." This frequently causes a great deal of annoyance and inconvenience on account of having to shut down the plant at some inopportune time when the requirements are exceptionally great.

It is through the general mechanical superintendent's office on this road that all requisitions are made for renewals and new shop equipment, and this office is the only proper place to maintain the records.

It was with the foregoing and other probable reasons, of which I have no knowledge in mind, that our general mechanical superintendent had the accompanying forms for stationary boilers, stationary engines, air compressors and shop air reservoirs made up. The forms need no explanation, as they show plainly the purpose for which they were designed.

Special men have been detailed to gather all necessary information to the proper filling out of the forms, and while in use but a short time, we are beginning to derive much benefit from them.

Form [illegible]

ERIE RAILROAD COMPANY.

NEW YORK, SUSQUEHANNA & WESTERN RAILROAD. CHICAGO & ERIE RAILROAD. NEW JERSEY & NEW YORK RAILROAD.

MECHANICAL DEPARTMENT.

SHOP AIR RESERVOIR RECORD.

Location ______ Builder ______ No ______

Jobber ______ Transferred or New ______ Req'n No. ______

P. A. Order No. ______ Spec. No. ______ Cost ______ Terms ______

Date Purchased or Made ______ Date Received ______ Date Installed ______

DESCRIPTION

Diameter Inside: Maximum ______	Stays: Diam. at Root of Thread ______
Length Inside: Maximum ______	Stays: Diam. at Body ______
Thickness of Sheets in Barrel ______	Stays: Spacing, Diametrically ______
Thickness of Sheets in Head ______	Stays: Spacing, Circumferencial ______
Heads: Dished or Straight ______	Stays: Number ______
Circumferential Riveting: Pitch ______	Safety Valve: Make ______
Circumferential Riveting: Diam. of Rivet ______	Safety Valve: Size ______
Longitudinal Riveting: Pitch ______	Safety Valve: Muffled or Open ______
Longitudinal Riveting: Diam. of Rivet ______	Safety Valve: Set at ______
Longitudinal Riveting: Thickness of Inside Welt ______	Blow-off Cock: Distance From Bottom Head to Center ______
Longitudinal Riveting: Thickness of Outside Welt ______	Blow-off Cock: Make ______
	Blow-off Cock: Size ______

MEADVILLE, PA., ______ 190__

ONE OF THE ERIE RAILROAD SHOP EQUIPMENT RECORDS.

PREHISTORIC BOILERMAKING.

Wherein It Is Related How Ambition, Incompetency and Sashweight Headers Led to the Confusion and Undoing of Two Ancient Artisans.

BY T. T. PARKER.

My friend Conroy, boiler maker and globe trotter, recently sent me an old manuscript, found, he states, in an ancient ruin at Memphis. He called attention to the hieroglyphics resembling certain features in boiler making. Fortunately, a neighbor is a professor of languages and through his courtesy I present below the translation:

A certain man named Dan, and Mike, his brother, were riveters and servants in the boiler shop of Soolivan, the rich man. Now Soolivan was like unto a giant, being nineteen hands in height and of vast girth, so that no man durst dispute him, and he was feared by all men. And it came to pass after Soolivan had spent four days at the brewery, he got an order for a sixty by sixteen, and there was a great drouth in the city during the four days. Then Dan and Mike went in unto Soolivan and pleaded they be allowed to lay out the boiler, saying: "Have we not been here for seven years serving thee, and shall we never be allowed to lay out a boiler? Behold, the men in the union say we are mere riveters and not boiler makers. Grant us, therefore, to lay out this boiler, so our name will stand among men, and that our reproach will be taken away."

Now, Soolivan was crafty and wise and did all the laying out for the shop, but being wearied by the prayers, and overcome with much drink, said unto them: "So be it, but see you make no mistakes, lest I fall on you and smite you offen the earth."

Therefore, Dan and Mike built the boiler, and when the inspector came, the water was on and it was tight, whereupon he ordered the water removed and entered the vessel with his little hammer, and when he came out, he scorned them, saying: "Go too, the boiler is no good, for the rivet holes are ½ inch out of line and were surely drifted. Cut out some rivets here," he ordered, "and see the holes."

And they did as he commanded and it was even so. Now, at this hour Soolivan was over to a place called Kronin's and they fetched him to the shop, and great fear fell on Dan and his brother Mike. And when Soolivan had seen all the details shown by the inspector, he was filled with rage, and seized Dan and his brother, Mike, and beat them sorely and threw them across the street, and they were as clay in the potter's hand before him. So he left them as dead men, and, with his friend Ryley, went again to Kronin's, cursing and bewailing, for the boiler was, indeed, a dead one.

When Dan and his brother Mike had come to, they went to a place called Schmid's, and were seen no more for four days, being exceedingly sore. And when the time had passed, they sat in Schmid's place counseling what they should do. And the door opened and a man dressed in fine linen, with patent-leather shoes, and a real Dunlap, entered. And he said unto Schmid: "Give to me drink and a good segar," and Schmid did so. Then the stranger said unto Schmid: "Have one on me," and Schmid had one and was elated. And the stranger said unto Schmid: "Know you the two men, Dan and his brother Mike?" And Schmid said: "Yah, dem two fellers by the table is dem."

Now, Dan and Mike pricked up their ears, fearing the stranger was to do them harm, and they were ready to flee. But he said unto them: "Have you an Aunt Kate out on the Archer Road?" And they said: "Yes." Then he said unto them: "Behold, she is dead and buried and has left much gold and silver. Go with me now to the Judge, and when all things are done lawfully the money is thine."

And it came to pass, the Judge did so, and they were given six thousand iron-men coin of the country. And they returned unto Schmid's and called in their friends, even from the yards, and there was great joy and much feasting for four days.

Now, when the feast was over, Dan and Mike counseled together and they went to the junk shop on Thirty-fifth street and bought tools of the man and journeyed afar, even to a city near the coal mines, and they started a boiler shop, for the yaps were easy and no inspector came. And they waxed rich and became great in that country. But the coal-mine men complained bitterly, saying: "Behold, your work is on the bum, and our money is wasted." And so work got slack.

Now, Dan said unto Mike: "Inasmuch as these people will not buy of us, let us seek others, and to do this, let us build Bee and Double boilers and sell them all over the world. And they counseled together and got some patterns at the old junk shop for this work. And they put in a cupola and took old grate bars, sashweights and cook stoves, with other junk, and made them into headers. And when she was assembled, behold the headers cracked when the tubes were expanded. And they went to the bank and got more money and built more headers, putting in heavier metal, so with care one could expand the tubes.

So they were puffed up and said: "Behold, we can make a Bee and Double boiler." And no man denied them. So they went out through the land and got an order for four two-fifties and built them, and Dan and Mike went out to see them erected. And the work was all done, when, on the fourth day of service, behold, the mud drum blew off the 4-inch tubes at the rear headers, and one man was killed and much property damaged.

Now, the mill owner sent for an inspector, and he came and condemned the outfit, saying: "The tubes are all too short, and the castings too brittle, and the workmanship savage." And when the mill owner heard all this, he said unto Dan and his brother Mike: "Take your junk and get you away from here, else the officers come and put you in prison."

And they went away sorrowful, for they had no more money. And they worked their way to the great city on the tracks, and when they had seen the rich man Soolivan and told him all the tale, he laughed and made merry. So they became again his servants as holder-on men, for the union

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Form 2033 3-4, '09—[illegible]

ERIE RAILROAD COMPANY.

NEW YORK, SUSQUEHANNA & WESTERN RAILROAD. CHICAGO & ERIE RAILROAD. NEW JERSEY & NEW YORK RAILROAD.

AIR COMPRESSOR RECORD

Location____ Type____ Shop No.____

Transferred or New____ Builder____ Jobber____

Date Purchased____ Date Received____ Date Installed____

Req'n No.____ P. A. Order No.____ Cost____ Terms____

DESCRIPTION

Air Inter-Cooler; Capacity, cu. in.____	Pipes: Size of Steam Inlet____
Belt Wheel: Diameter____ face____	Pipes: Size of Steam Exhaust____
Circulating Water System: kind____	Pipes: Size of Air Discharge____
Capacity: cu. ft. free air per min.____	Pipes: Size of Circulating Water____
Capacity: cu. ft. free air per rev.____	Packing: Cylinder, Kind____
Cylinders: Air, H.P. Diameter____	Packing: Piston Rod, Kind____
Cylinders: Air, L.P., Diameter____	Packing: Valve Stem, Kind____
Cylinders: Steam, H.P., Diameter____	Piston Rod: Diameter____
Cylinders: Steam, L.P., Diameter____	Pressure: Air____ Steam____
Cylinders: Stroke____	Speed: R. P. M.____
Floor Space: Total Length____ Total Width____	Speed: Piston, Ft. per min.____
Floor Space: Height above Foundation____	Shaft: Diameter____
Fly Wheel: No.____ Diam.____ Face____	Throttle: Type____ Size____
Governor: Type____ Size____	Valve Gear____
Horse Power____	Valves: Steam, Type____
	Valves: Air, No.____ Size____

MEADVILLE, PA.____ 19____

AIR-COMPRESSOR RECORD, ERIE RAILROAD.

was on a strike and Soolivan was hard pressed and they remained with Soolivan even unto this day.—*Power and the Engineer.*

THE WORKING OF THE BOILER EXPLOSIONS ACTS.*

The annual report for the year ending June 30, 1908, on the working of the boiler explosions acts, 1882 and 1890, has just been issued by the Board of Trade. During the term covered by the report 62 preliminary inquiries and 11 formal investigations have been held under the provisions of the acts. Of these 73 explosions, 36 resulted in loss of life or personal injury—23 persons being killed and 50 injured. The number of explosions is slightly above the average for the previous twenty-five years, but the number of persons killed, and the number injured, are below the average.

Of the 73 explosions reported on, 47 occurred on land and 26 on board ship. By 31 of the explosions on land, 20 persons were killed and 42 injured, while by the remaining 16 no death or injury was caused. By 5 of the explosions, which occurred on board ship, 3 persons were killed and 8 injured, but by the other 21 explosions no death or injury was caused.

In 39 cases the boilers, etc., were not inspected or insured; in 23 cases they were insured under boiler or vessel insurance companies; while in the remaining 11 cases they were under Lloyd's Register or the Board of Trade, etc.

Appendices B. C. and D, added to the report by Mr. R. Ellis Cunliffe, the solicitor to the Board of Trade, give some further interesting information. Appendix B gives the causes of the 73 explosions, from which it appears that more than one-third of the total number of explosions were due to deterioration or corrosion, and one-half the cases in which no inspection had been made were attributed to this cause. The details are as follows:

29 Deterioration or corrosion.
9 Defective design, or undue working pressure.
11 Water-hammer action.
9 Defective workmanship, material, or construction.
12 Ignorance or neglect of attendants.
3 Miscellaneous.

The 73 explosions are classified as having arisen from the following boilers, etc.:

16 Horizontal, multitubular.
8 Vertical.
7 Cylindrical, Cornish, Lancashire, etc.
2 Locomotive.
2 Watertube.
2 Tubes in steam ovens.
4 Heating apparatus.
23 Steam pipes, stop-valve chests, etc.
9 Miscellaneous.

Appendix C states that the 11 formal investigations held during the year related to

3 Cylindrical vertical boilers.
1 Watertube marine type.
2 Cylindrical, internally fired.
2 Cornish.
1 Cast iron steam pipe.
1 Steam stop valve.
1 Blow-off tank.

The explosions resulted in the death of 17 persons and in injury to 19 others.

The causes of these explosions were clearly ascertained, and in no case was the explosion attributable to unavoidable accident. One was found to be due to the carelessness and neglect of the late owner and the owner at the time of the explosion and her manager; one was due to neglect of an engineer and an insurance company's inspector; in three cases the owners were to blame; in one a foreman of the works was to blame; in four cases engineers were to blame; in one case a boiler fireman was to blame; in another case a mechanic was to blame; one case was due to "water-hammer," for which nobody was held to blame; and in one case a superintendent was held responsible for an oversight in the supervision of the cleaning of the boiler.

In four of the cases the boiler owners were ordered to pay, respectively, £30, £35, £50, and £60; in two cases owners were ordered to pay £20; in another case an insurance company was ordered to pay £20; a foreman and a mechanic were each ordered to pay £5, and two engineers £15 and £20, respectively, while a manager was ordered to pay £15. The gross total amounted to £295. In three cases in which formal investigations were held, no order was made as to costs.

Appendix D gives the total number of explosions dealt with since the passing of the acts, the number of lives lost and persons injured, as follows:

Year.	Number of Explosions.	Personal Injuries.		
		Number of Lives Lost.	Number of Persons Injured.	Total.
1882-1883	45	35	33	68
1883-1884	41	18	62	80
1884-1885	43	40	62	102
1885-1886	57	33	79	112
1886-1887	37	24	44	68
1887-1888	61	31	52	83
1888-1889	67	33	79	112
1889-1890	77	21	76	97
1890-1891	72	32	61	93
1891-1892	88	23	82	105
1892-1893	72	20	37	57
1893-1894	104	24	54	78
1894-1895	114	43	85	128
1895-1896	79	25	48	73
1896-1897	80	27	75	102
1897-1898	84	37	46	83
1898-1899	68	36	67	103
1899-1900	59	24	65	89
1900-1901	72	33	60	93
1901-1902	68	30	55	85
1902-1903	69	22	67	89
1903-1904	60	19	45	64
1904-1905	57	14	40	54
1905-1906	54	25	21	46
1906-1907	77	28	65	93
1907-1908	73	23	50	73
Totals	1778	720	1510	2230
Average of 26 years	68.4	27.7	58.1	85.8

Length of Locomotive Boiler Barrels.

A correspondent to *The Engineer* raises the question of the thermal usefulness of such long boiler barrels as are necessitated by the construction of the new Mallet locomotives for the Southern Pacific Railway. Having regard for a recent discussion upon the economical length of the locomotive boiler tube, he suggests that one could commence by cutting off the useless last 5 feet of the tubes in the boiler mentioned, so as to increase the space available for sections of naturally diminishing temperatures suited to a variety of purposes. Using tubes 16 feet long, he ingenuously suggests that the boiler length might be utilized as follows:

	Feet.	Inches.
For the combustion chamber.........	4	0
For the feed-water heater...........	4	6
For a sand drier.....................	2	3
For a food-warming compartment.....	2	0
For a clothes-drying compartment.....	2	0

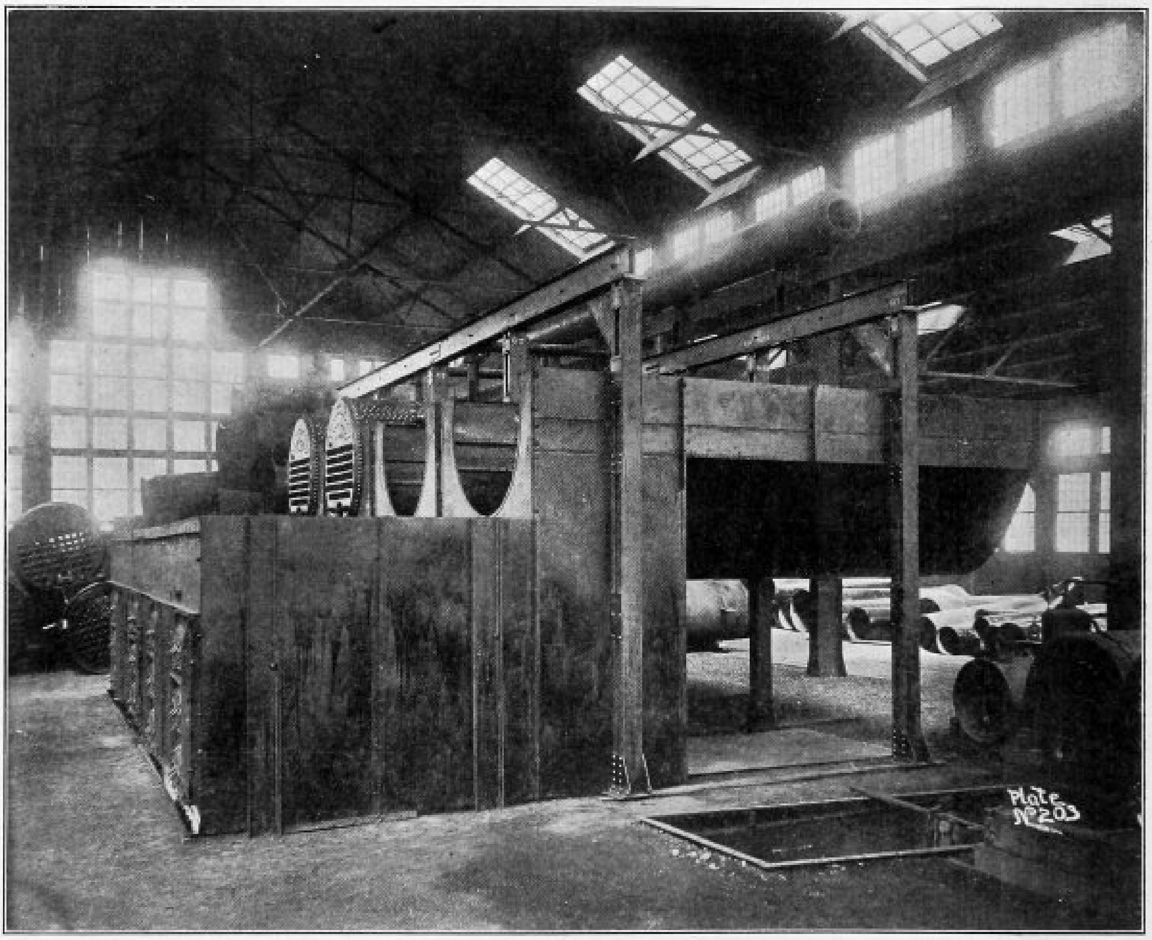
There being little heat left for the superheater, this space could be utilized to serve as a refrigerator for preserving perishable articles of food for use in a dining car on a long journey.

* From *Engineering*.

STEEL BOILER SETTINGS.

The steel-encased boiler is a very old device. It originated in the steam practice on the Ohio and Mississippi Rivers, where horizontal flue boilers with maximum power and with minimum weight are essential. Such casings are now universally employed on these rivers, and they are made quite thin to reduce the weight. They are rectangular in form, both around the fire-box and the combustion chamber, being supported below the combustion chamber by means of adjustable struts or jacks.

The application of this type of casing to the standard high-pressure horizontal tubular boiler began in the South. Familiarity with river practice showed how boilers could be set with a minimum amount of brickwork. In some portions of the South brick is hard to obtain, and the expense of transportation almost makes the price prohibitive. By using steel casings with the necessary firebrick the usual amount of common brick is greatly reduced.



STEEL SETTING FOR BATTERY OF BOILERS WITH DUTCH OVEN FURNACES.

In general practice it is the custom to support large boilers from beams overhead, supported on columns. This, taken in connection with the steel casing, makes a very compact and substantial form of construction. The earliest steel casings erected in the South were made of semi-circular form under the combustion chamber, this form being maintained by means of stiffening angle irons, and the entire weight of casing and lining of combustion chamber was supported from the ground by means of a number of posts or castings. The Houston, Stanwood & Gamble Company, Cincinnati, have designed a form of casing by which the entire weight of the steel casing and the brick lining of the combustion chamber is entirely supported by the columns which support the boiler. This renders unnecessary any special foundation beneath the combustion chamber and requires only a light footing for the furnaces, with heavy piers for the columns. The bag sheet which supports the brick lining of the combustion chamber is made in catenary form, which requires no stiffening braces, and the entire weight is carried by the upper edges of the catenary sheet, which are secured to horizontal channel beams, which, in connection with the rear beam, constitute a horizontal framework midway around the boilers.

These plates and sheets forming the casing are fastened together by means of small bolts, so that in erection no rivets are necessary and no holes have to be punched. By this means the boilers can be erected by a mechanic and helpers, and the firebrick lining can even be put in by them if a mason is inaccessible.

These casings are also adapted to boilers in large batteries with Dutch oven furnaces; in fact, furnaces can be constructed of such a design and encased for almost any type of fuel, high or low grade.

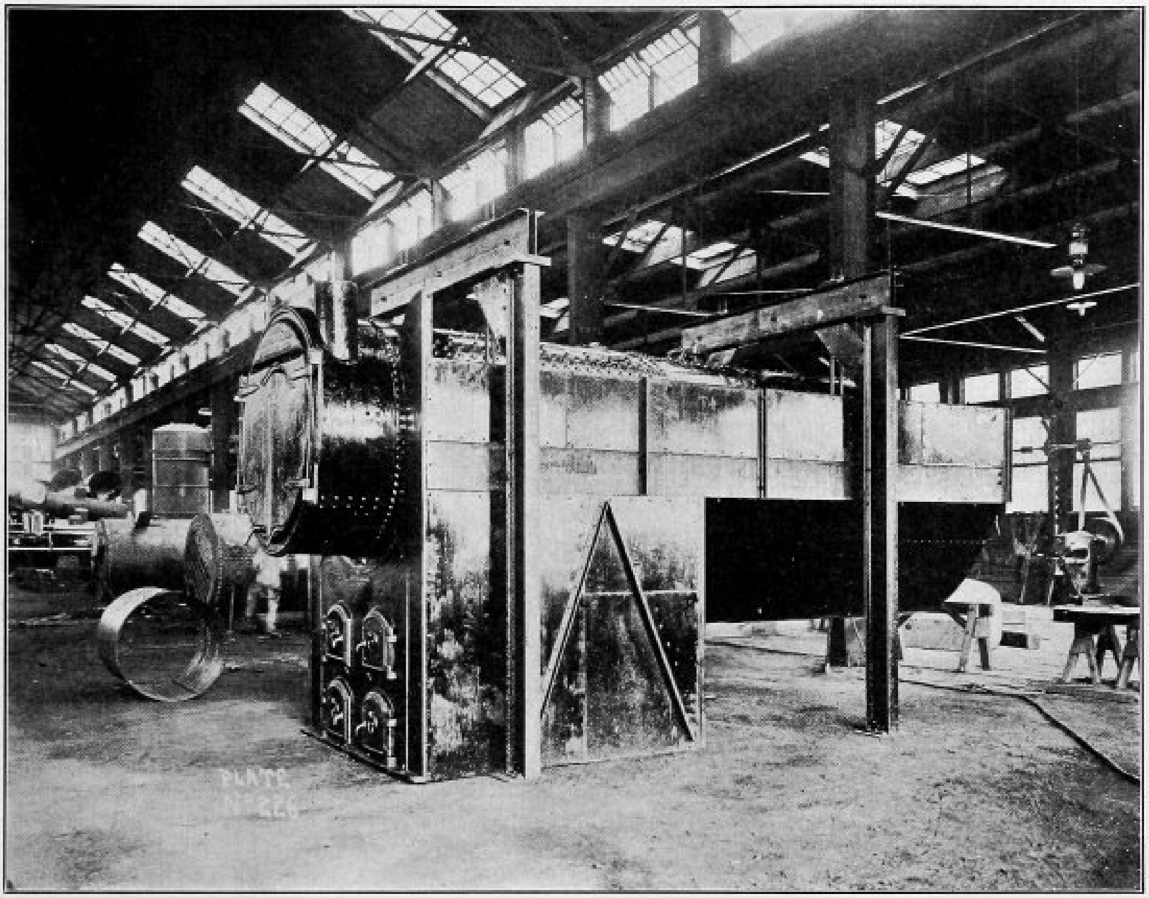
The durability of casings of this type is undoubted. In most cases on the river they have outlasted two sets of boilers. There is nothing to rust them or to seriously burn them out, if anything like reasonable care is taken of them. Cracked settings with air leaks are obviated, and the amount of radiation with this casing is remarkably small; in most cases it is found possible to bear the hand against the casing.

The advantages of the steel casing may be summed up as follows: It eliminates nearly all of the common brick, only the firebrick lining being retained; considerable reduction in space is secured, especially in the case of batteries; there are no air leaks and no brick walls to crack; the labor difficulty in using a large force of brick masons required in isolated localities is avoided; light weight is secured which adapts the ordinary horizontal tubular boiler to boats, elevated structures, etc.; boilers and casings can be easily taken down and re-erected without the loss and expense incidental to removal of brick setting; the boiler casing and setting is very durable and makes an exceedingly attractive installation; in cramped space the space below the rear of the boiler is available for pumps and return tanks.

ITALIAN BOILER REQUIREMENTS.

Consul Albert H. Michelson, of Turin, furnishes the following report for the information of American manufacturers concerning the laws and regulations of Italy governing the construction and use of boilers:

The attention of American manufacturers of stationary and portable boilers, locomotives, locomobiles, steam rollers, steam automobiles, steam agricultural machinery, house-heating boilers, retorts, stills and condensers, and accessories and parts of all these, is drawn to the requirements in force in Italy governing the construction and use of boilers of all classes, which are rigidly enforced and must be most carefullly observed.



STEEL SETTING APPLIED TO SINGLE BOILER, SHOWING AVAILABLE SPACE FOR PUMPS AT REAR.

An Efficient Flue Plant.

The horning, safe ending, welding and swagging of 500 flues is considered an ordinary 9-hour day's work for two men, using but one furnace in the flue department of the Lake Shore & Michigan Southern Railway shops at Collinwood.

Fag ends are cut off by an abrasion saw, the cutting wheel of which is of tank steel 3/32 inch thick and 18½ inches diameter, driven at the rate of 4,280 revolutions per minute by a 10-horsepower motor through gearing and a belt drive. As the fag ends are cut off, the flues are piled in a rack, from which they are transported by a traveling crane to a rack nearer the flue-welding machine.

After being brought to the proper heat, it is welded in a McGrath welder, and while still hot is swagged to the proper size. The flue is then rolled backward and slides into a rack.—*American Engineer and Railway Journal.*

The following abstracts from these laws and regulations cover their principal requirements, as far as American manufacturers are concerned:

Every new or rebuilt boiler must be officially inspected and tested before use; every boiler must be inspected not less than once in four years, and every boiler for a steam engine must be in charge of a duly qualified person.

All receptacles used for changing liquids into vapor at a pressure greater than atmospheric pressure, and all receptacles containing vapor at a pressure greater than atmospheric pressure, shall be deemed steam boilers.

CONSTRUCTION OF BOILERS.

The use of cast iron or sheet brass for parts exposed to fire is prohibited. Exception is made for brass tubes less than 10 centimeters (3.94 inches) in diameter, and for cast iron parts less than 25 centimeters (9.84 inches) in diameter if cylindrical in form, and less than 30 centimeters (11.81 inches) in diameter if spherical in form.

The use of cast iron is permitted for steam domes, boiler heads, covers for manholes, cleaning holes and mud collectors for economizers, and for parts of other similar contrivances; provided, however, that these are not inclosed in masonry nor in contact with fire, and that they are not greater than 70 centimeters (27.56 inches) in diameter.

SAFETY VALVES.

Every boiler shall be fitted with at least two safety valves charged in such a way as to permit the steam to escape as soon as the maximum effective pressure shall have been reached.

In stationary and semi-stationary boilers the valves shall be charged by a weight applied either directly or at the end of a lever. The weight and the length of the arms of the lever, as fixed by official test, shall not for any reason be increased by the person using the boiler, or by any person dependent upon him.

In portable boilers, boilers for launches, and in reversible and balancing receptacles the valves may be charged by direct-acting springs, or by spring balances applied to the ends of levers. In this case, however, the springs shall be of such sensibility that when the normal pressure increases one-tenth, each spring, acting by itself, shall permit the escape of all the steam produced. The stroke of the spring balance, fixed by official test, shall be made invariable by appropriate means.

PRESSURE GAGES.

Every boiler shall be fitted with a good pressure gage, conveniently placed and within easy reach of the fireman, graduated in kilograms, upon which shall be well and visibly marked the maximum effective pressure that the steam may not exceed.

In boilers used to produce steam at an effective pressure not greater than ½ kilogram (1.10 pounds) per square centimeter (0.155 square inch), an open tube, with a minimum internal diameter of 80 millimeters (3.15 inches) and a maximum height of 5 meters (16.40 feet) above the level of the water in the boiler, may be substituted for safety valves and pressure gage.

Every boiler shall, further, be fitted with a suitable connection for attaching a controlling pressure gage. The extremity of this connection shall be provided with a flat, circular disc, 40 millimeters (1.576 inches) in diameter and 5 millimeters (0.197 inch) thick.

FEEDERS AND STEAM MAINS.

Every boiler shall be fitted with two independent feeding contrivances, each equally able to supply in abundance the water required, and shall be provided with automatic check valves placed at the entrance of the feed pipes into the boiler. For portable boilers, however, one feeding apparatus may suffice, if upon inspection it appears exceedingly difficult to attach two appliances.

For a series of intercommunicating boilers two feeding appliances may be deemed sufficient, provided that they are independent of each other and that each is equally able to supply in abundance the water required for all the boilers.

It shall be possible, when a number of boilers furnish steam to one and the same steam main, to disconnect any one boiler from the others, whether as to feeders or outflow.

WATER GAGES.

Every boiler must have not less than two gages for determining the level of water, one of which shall be in the form of a glass tube. The gages shall be in direct communication with the interior of the boiler and shall be independent each from each. The said gages may be mounted on one and the same cylindrical body, provided that this and the pipes which connect it with the boiler shall have a free cross-section of not less than 60 square centimeters (9.30 square inches). The glass-tube gage shall be so placed as to be easily cleaned and replaced.

The gages shall be marked with a fixed and visible sign showing the minimum level that the water in the boiler may reach.

For stationary boilers the minimum level mentioned in the preceding article shall be 8 centimeters (3.15 inches) above the upper line of the fire flues and shall be indicated by a clearly visible line marked on the outside of the boiler.

For portable boilers the minimum level shall be fixed with due regard to possible oscillation and to the necessity that the fire flues never remain uncovered by water.

The provisions of the preceding article do not apply to those flues in which the overheating of parts in contact with steam is not to be feared.

House-heating boilers need not be inspected in accordance with the regulations of August 17, 1907, if they comply with the following conditions: (*a*) That they be built of sheet iron or mild steel; (*b*) that their interior be in direct and continuous communication with the air by means of an open tube, accessible and visible throughout its length, in order that continuous and immediate supervision may be exercised; (*c*) that the said tube have an internal diameter of not less than 80 millimeters (3.15 inches), and a height of not more than 3 meters (9.84 feet) above the normal level of the water in the boiler.

The original Italian texts of the laws and regulations cited in this report are on file in the Bureau of Manufactures.—*Consular and Trade Reports.*

Layout of an Irregular Pipe Intersecting a Large Cylinder at Right Angles.

BY C. B. LINSTROM.

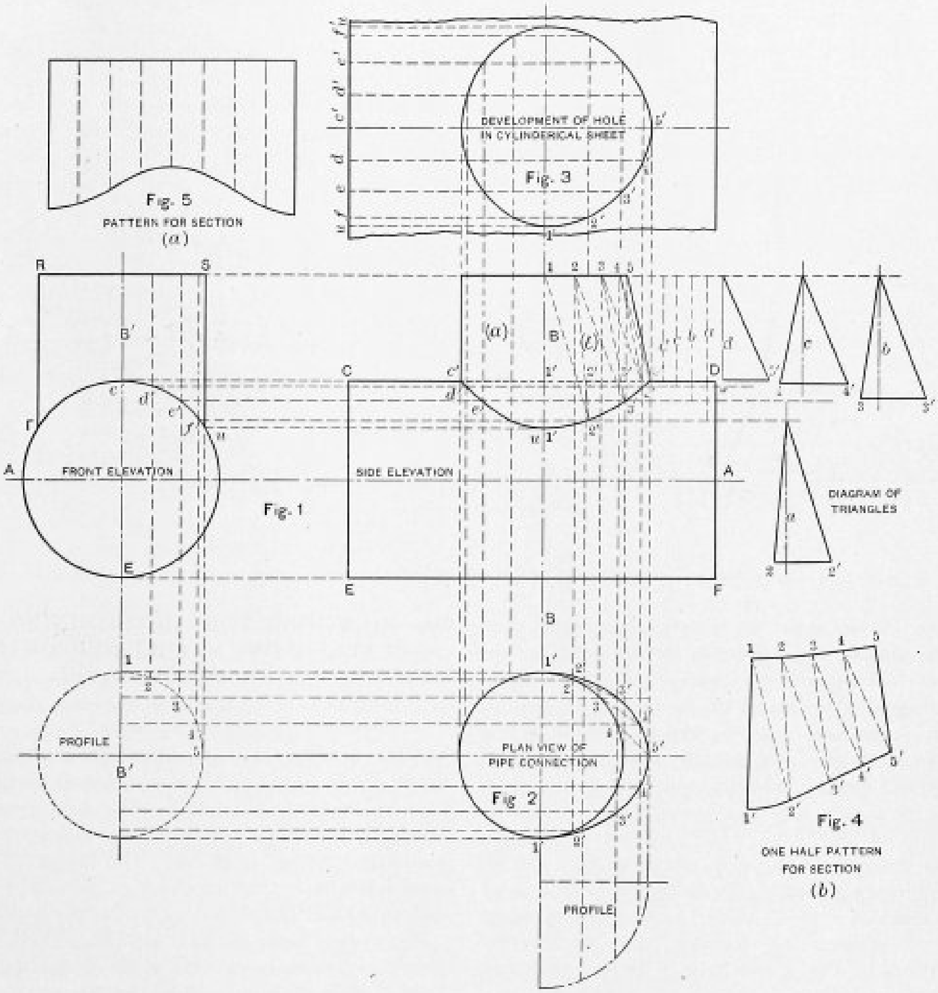
The conditions that are covered by this problem are met with quite frequently in sheet metal work, and it is given here for the purpose of showing how the principles of projection and triangulation drawing are applied to irregular pipe intersections. There are innumerable forms of connections encountered, but the same general principles enter into similar constructions which are found in the every-day workshop practice.

It will be noted, by referring to the respective views, especially the side elevation, how this connection is made, but before going into the details of its construction it may be well to explain the form or shape of the connecting pipe; this may be well understood by referring to Fig. 1, side elevation, and to Fig. 2, designated "plan view of pipe connection." The portion of the problem as shown at (*a*) Fig. 1, side elevation is a regular development, which means that the developers used for its construction are shown in their true length in either an end or side elevation, or an elevation which is at right angles to the line of sight. The plan view for this portion of the object is shown to the left of the line 1-1, and can very readily be developed by projection drawing. The portion as shown at (*b*), however, is a construction which will necessitate the drawing of an elevation and plan in order to determine the correct length of lines for the development of the pattern; hence, the drawing of the plan view. The part as shown at (*b*) and the portion shown to the right of the line 1-1 shows how the irregular portion of this connection is determined.

CONSTRUCTION.

The first essential requirement in any drawing, whether in laying out or drafting, is to locate the respective center lines. This forms the foundation of our development upon which the remainder of the drawing is determined: Consequently, in this case we draw the lines *A A*, *B B* and *B' B'* convenient in length and at right angles to each other. Upon these center lines locate the front and side elevations to the required dimensions as shown at *C*, *D*, *E*, *F*, *R*, *S*, *T* and *U*, Fig. 1. Below the front view upon the line *B' B'* draw a profile equal in diameter to the top of the small connecting pipe, which is equal to the distance *R* to *S*. Divide one-quarter of its circumference into any number of equal spaces; in this case 4, numbered from 1 to 5, inclusive. Project these points of division parallel with the line *B' B'* until they intersect the line *R S*. The lines for *R S* to the respective points *c*, *d*, *e*, *f*, and *u*, are the true lengths of lines for the development of the pattern as shown at Fig. 5. The next requirement is to complete the side elevation, but in order to do so it is necessary to draw the plan view for the pipe connection, Fig. 2. This is done in the following manner: Below the side elevation upon the line *B B*, draw the small circle with a radius equal to one-half the diameter of the top of the small cylinder; then locate the profile below this circle Fig. 2, which is drawn with a radius equal to the distance 1 to 5 of the side elevation. Divide this arc into the same number of equal spaces as are shown in the profile below the front elevation. Extend these points of division to the line *C D*, side elevation. At right angles to the line *B' B'* project the points of division from the profile front elevation until they intersect the corresponding lines or projectors which were extended to the line *C-D*. A line traced through these respective points completes the plan view for the small pipe. Projections from the small circle plan view are then drawn through the side elevation until they intersect the line which represents the cutting plane for the top of the pipe.

Referring to the portion (*b*), connect the points 2 to 2', 3 to 3', 4 to 4', with solid lines of an indefinite length. It is then required to ascertain the connecting plane or miter line between the two pipes. This operation is done in the following manner. At right angles to the line *B' B'*, and through the points *c' d' e' f'* and *u*, projectors are drawn until they intersect the corresponding solid lines which were drawn



through the points to 1 to 1', 2 to 2', 3 to 3' and 4 to 4'. A line traced through the intersection of these lines determines a foreshortened view for the plane of connection, between the small and the large pipe. Dotted construction lines are then drawn in as shown from 1 to 2', to 2 to 3', 3 to 4', etc., in both the plan and elevation.

The next procedure necessary for the completion of the problem is the drawing of Fig. 3 and the diagram of triangles. Fig. 3 represents the hole in the pattern for the large cylinder sheet; and its development is determined in the usual manner by projection drawing. First locate the center line (*c'*), and on either side locate the distance *c'* to *d'*, *d'* to *e'*, *e'* to *f'* and *f'* to *u*. These distances are obtained from the end elevation taken on the circumference of the large cylinder between the points *c'* and *u*. At right angles to the line *u u*, Fig 3, draw the horizontal lines from the points *d'*, *e'*, *f'* and *u*, indefinite in length. Corresponding lines are then projected from the side elevation until they intersect the horizontal lines c', d', e', f' and u. A line traced through these points completes the development for the holes. This layout is very essential, as the spaces for the development of the pattern for the portion shown at (*b*) are taken from this view. It is the general rule, when taking the distances or transferring the spaces, to use the chord distances. The chord distances are not the true lengths, but are close enough to answer.

connection is obtained by transferring the true length of lines from the front elevation as shown.

The pattern for the entire connection can be made in one piece, or the patterns for (*a*) and (*b*) can be made and then riveted together.

The construction of the different triangles required in this development is determined exactly in the same way as explained for similar triangulation problems. The method, therefore, should not prove complicated.

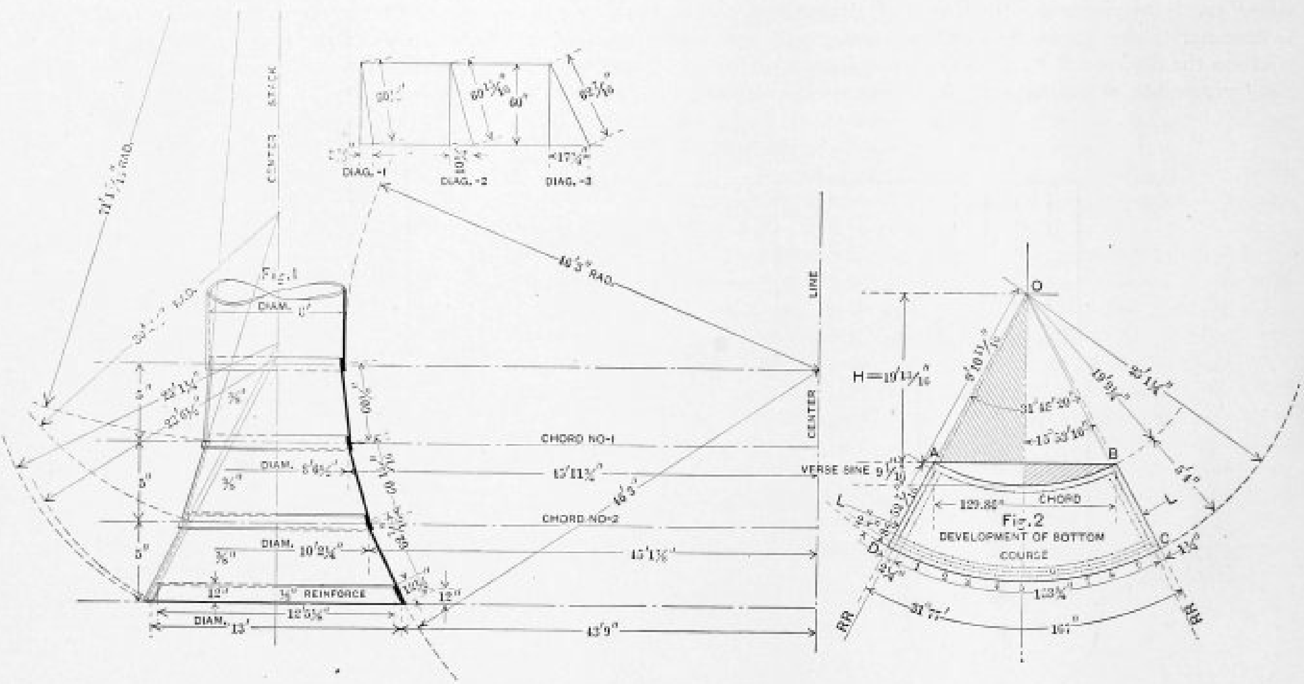


DIAGRAM SHOWING DIMENSIONS OF STACK BASE AND LAYOUT OF ONE OF THE PLATES.

The constructing of the diagram of triangles is the next procedure. The heights for each respective triangle are shown at *a*, *b*, *c* and *d*, are taken from the elevation; the true lengths of solid line are shown to the left of the heights *a*, *b*, *c* and *d*, and the dotted lines are located to the right. The bases for these required lines are taken from the plan view. A line connecting the height and base is the required line.

DEVELOPMENT OF PATTERN.

The pattern for the part of the pipe shown at (*b*) will be developed first and in this manner: Draw the line 1 to 1 equal in length to the distance 1 to u' of the side elevation, or to the distance *R* to *T* of the front elevation. Set the dividers equal to the space 1 to 2', Fig. 3, and using 1' in the pattern as a center, draw an arc. Then with the trammel points set equal in length to the dotted line of the triangle (*a*), and using (1) in the pattern, draw an arc through the arc previously drawn. Continue in this manner, using alternately the true dotted and solid required lines until the pattern is complete. The spaces for the top of the connection are taken from the small circle or profile of either the front elevation or plan view.

The pattern for (*a*), as shown in Fig. 5, is obtained by projection drawing. Since all data for its development have been determined, it will only require the laying out of Fig. 5 to complete the entire problem. It is first necessary to draw a stretch-out line equal in length to one-half the circumference of the profile, as shown in the front elevation. Divide its length into the same number of equal spaces; through these points and at right angles to the stretch-out line draw lines of an indefinite length. The camber line for the

CALCULATIONS FOR DETERMINING THE SIZE OF PLATES FOR A SELF-SUPPORTING STEEL STACK BASE.

BY J. N. HELTZEL.

Many articles have been written on stack design and the development of plates for stacks, but as yet the subject has not been treated in full detail. The following calculations are essential in making the necessary estimates for ordering the plates and laying them out. The layout of a self-supporting steel stack base, with an outside diameter of 8 feet at the top and an inside diameter of 13 feet at the bottom, is shown.

We wish to make the base bell shaped and in conical courses; therefore, in outline, points at the horizontal seams as well as at the top and bottom will be tangent to a certain radius. See Fig. 1. Suppose the base to be 15 feet high and constructed of ⅜-inch material. The radius of the circle which will be tangent to the four points on Fig. 1 is determined by the following formula:

D = difference between top and bottom radius of stack.
H = height of base.
R = radius desired.

$$R = \frac{\frac{H}{D} \times H + D}{2} = \frac{\frac{15}{2.5} \times 15 + 2.5}{2} = 46.25$$

We find the radius to be 46.25 feet.

We will now calculate the different diameters of the base at the horizontal seams. This is done by first calculating the different lengths of the half-chords of a circle whose diameter is 92.5 feet.

R = radius of circle tangent to top and bottom of base.
H = height of course.
C = chord No. 1.

$C = \sqrt{R^2 - H^2} = \sqrt{46.25^2 - 5.0^2} = 45$ feet $11\frac{3}{4}$ inches.

The radius of the base at the large end of the top course will be 46 feet 3 inches + 4 feet 0 inches — 45 feet $11\frac{3}{4}$ inches = 4 feet $3\frac{1}{4}$ inches, and the diameter 8 feet $6\frac{1}{2}$ inches.

Chord No. 2 = $\sqrt{(46 \text{ feet } 3 \text{ inches})^2 - (10 \text{ feet } 0 \text{ inches})^2}$ = 45 feet $1\frac{7}{8}$ inches.

The radius of the large end of the center course will be 46 feet 3 inches + 4 feet — 45 feet $1\frac{7}{8}$ inches = 5 feet $1\frac{1}{8}$ inches, and the diameter 10 feet $2\frac{1}{4}$ inches.

This completes the diameters of the different courses at the horizontal seams between the laps on points of contact of the two plates. The next step will be to calculate the slant height of the different courses on a line through the center of the thickness of the plate. The neutral diameter of the small end of the top course equals 8 feet — $\frac{3}{8}$ inch = 7 feet $11\frac{5}{8}$ inches.

The neutral diameter of the large end of the top course equals 8 feet $6\frac{1}{2}$ inches + $\frac{3}{8}$ inch = 8 feet $6\frac{7}{8}$ inches

$$\frac{8 \text{ feet } 6\frac{7}{8} \text{ inches} - 7 \text{ feet } 11\frac{5}{8} \text{ inches}}{2} = \frac{7\frac{1}{4} \text{ inches}}{2} = 3\frac{5}{8}\text{-}$$

inch, base of a right-angle triangle. (See Diagram 1.)

B = Base of triangle.
H = height of course.
S = slant height of ring.

$S = \sqrt{H^2 + B^2} = \sqrt{(5 \text{ ft.})^2 + (3 \text{ ft. } \frac{5}{8} \text{ in.})^2} = 5$ ft. $\frac{1}{8}$ in.

Thus the slant height of the top course is 5 feet $\frac{1}{8}$ inch. The slant heights of the remaining two courses are calculated in a similar manner. By referring to Diagram 2 it will be seen that the difference between the neutral diameter of the large and small end is 1 foot $8\frac{1}{2}$ inches. One-half of this is $10\frac{1}{4}$ inches for the base of the triangle. (Diagram 2.) The slant height of the middle couse is 5 feet 15/16 inch. Using the same calculations for determining the slant height of the bottom we find it to be 5 feet 2 7/16 inches. (See Diagram 3.)

The next step will be to determine the radius of the camber of the different sheets to make the courses. It is only necessary to calculate the camber of the large end of each course.

D^s = neutral diameter of small end.
D^l = neutral diameter of large end.
S = slant height of the course through center of thickness of plate.
R = radius of camber sheet.

$$R = \frac{D^l}{D^l - D^s} \times S =$$

$$\frac{8 \text{ ft. } 6\frac{7}{8} \text{ ins.}}{8 \text{ ft. } 6\frac{7}{8} \text{ ins.} - 7 \text{ ft. } 11\frac{5}{8} \text{ ins.}} \times 5 \text{ ft. } \tfrac{1}{8} \text{ in.} = 71 \text{ ft. } 1\ 5/16 \text{ ins.}$$

According to the above calculations we have a radius of 71 feet 1 5/16 inches for the camber of the large end of the top course.

The cambers are determined by the same formula for the other sheets. It will be noted that if the thickness of the plate is added to the large diameter, and if the thickness of plate is subtracted from the diameter of the small end, the result is the neutral diameter.

Referring to Fig. 1 will be seen that the radii of the cambers are

Top course, 71 feet 1 5/16 inches.
Middle course, 30 feet $2\frac{1}{2}$ inches.
Bottom course, 25 feet $1\frac{1}{4}$ inches.
Reinforcement, 23 feet $6\frac{1}{2}$ inches.

The radii of the different cambers are calculated from the neutral diameter of the courses. This is essential in determining the exact camber.

We will now take up the development of one of the bottom plates and also the calculations necessary in ordering the sketch plates. The writer finds it good practice to mark the results of the foregoing calculations on the blue print as well as the circumference of each course at the large and small end. There is but one calculation used in figuring the size of plates that is not used in the development of same, and that is the chord of the arc at the small end of the course. (See Fig. 2.)

As an illustration, we will consider the bottom course made of three sheets to the course. The circumference of the bot-

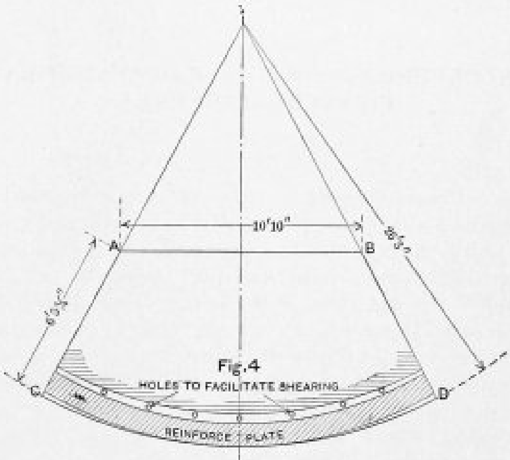


Fig. 4

tom of the base, whose neutral diameter is 13 feet $\frac{3}{8}$ inch, divided by 3, will give the length of one sheet at the rivet line.

$$\frac{13 \text{ ft. } \frac{3}{8} \text{ in.} \times 3.1416}{3} = 163\tfrac{3}{4} \text{ inches length of one sheet at}$$

large end at rivet line. To this add enough stock for laps, making the sheet 167 inches around the camber. From the latter dimension we would determine the length of the chord at the small end, so it will be necessary to find the number of degrees there are in the arc whose radius is 25 feet $1\frac{1}{4}$ inches and length 167 inches.

A = length of arc.
C = circumference of circle of which the arc is a part.
D = degrees in arc.
360 = degrees in circle.

$$D = \frac{A}{C} \times 360 = \frac{167}{1892.81} \times 360 = 31.77 \text{ degrees.}$$

Therefore, the degrees in arc are 31.77, or 31° 46′ 20″

$$\frac{31° \ 46' \ 20''}{2} = 15° \ 53' \ 10'' = \text{one-half the arc.}$$

C = the chord of arc at small end.
S = sine of the angle of 15° 53′ 10″.
R = radius of the arc.
$C = S \times R \times 2 = .27368 \times 19$ ft. $9\frac{1}{4}$ ins. $\times 2$ = 10 ft. 9.86 inches; therefore, the chord is 10 ft. 9.86 inches.

The next step will be to find the depth of the camber, which is known as the versed sine. The versed sine is determined by the following formula:

V = versed sine.
R = radius of the arc.
C = one-half the chord of the arc.
H = height of the angle.
$V = \sqrt{R^2 - C^2} - H.$
$V = \sqrt{(19 \text{ ft. } 9\tfrac{1}{4} \text{ ins.})^2 - (5\text{ft. } 4.83 \text{ inches})^2} - H$
$= 9\ 1/16$ inches.

Thus the versed sine is 9 1/16 inches. This completes the calculations for the article in question.

The plate, as we would order from the mill, would be *A*, *B*, *C*, *D*, Fig. 2. There will be a saving of material if the reinforce straps are ordered on the sketch plate, Fig. 2, along the large end. The size of the sheet is shown, Fig. 4, after the reinforce sheet has been added. Then *A*, *B*, *C*, *D* will be the size sheet to order. The two different pieces can be laid out at the same time, punched and sheared, and there will be no extra labor added.

AN EXPERIENCE WITH LEAKY VERTICAL FIRETUBE BOILERS.*

BY F. W. DEAN.

In 1905 I made a design for a large, vertical firetube boiler, two of which were built, to be placed on a brick fire-box provided with a chain grate. In accordance with a great number of precedents the water-leg was short; being, in fact, 2 feet deep below the underside of the crown sheet. Unusual provision was made for easy circulation by wide spaces between tubes at every 45 degrees of the circumference instead of the customary 90 degrees, or as in some cases at 180 degrees. The distance from the top of the grate to the underside of the crown sheet was 7 feet. The following are the general dimensions of the boilers as they now are:

Inside diameter of smallest course of shell	120⅞ ins.
Inside diameter of largest course of shell	122 11/16 ins.
Inside diameter of water-leg	112 ins.
Height of water-leg	7 ft. 2¾ ins.
Height of brick furnace	5 ft. 8 ins.
Distance from grate to tube plate	12 ft. 2¾ ins.
Outside diameter of tubes	2½ ins.
Length of tubes	20 ft.
Number of tubes	488
Pressure for which the boiler was designed	165 pounds
Kind of grate	B. & W. chain
Size of grate	8 ft. 6 ins. by 9 ft.
Grate area	76.5 sq. ft.
Water heating surface, say	4,900 sq. ft.
Superheating surface	1,181 sq. ft.
Total heating surface	6,081 sq. ft.

The boilers were designed for S. D. Warren & Company, and were used in their paper mill at Cumberland Mills, Me. They were built by the Portland Company, of Portland, Me. Each boiler was rated at 500 horsepower, or substantially 1 horsepower for every 10 square feet of water-heating surface, and was expected to work at 1,000 horsepower a good portion of the time. Artificial induced draft was used, and it was possible to obtain a draft of 2½ inches of water in the smoke-box.

At the back end of the chain grate, instead of a water back or a brick back, a vertical or slightly inclined common grate was used, against which the unconsumed coke would accumulate, and under which the ashes would pass and fall upon the ash-pit floor. Difficulty was found in making the coke accumulate uniformly, and the ends of this grate were frequently bare.

The boilers were started gently and then operated at high capacity. After about two weeks a number of the tubes began to leak at the lower ends. They were expanded, but shortly began to leak again, and this process was repeated until the tubes were so injured that they could not be further expanded. They were then removed and new ends were welded on, but after a comparatively short time they leaked again. The leaks were more on the back-half of the boilers than on the front. In winter, when a nearby door in the building was open and cold air blew on the vertical grate, when the ends of the grate were bare, the leakage would increase. After learning how to keep the vertical grate covered, and keeping the door closed, the general trouble continued.

Knowing the sensitiveness to dirt on the crown sheet of vertical firetube boilers, as the design permitted access to the interior, these crown sheets were examined and found to be clean. Thinking that possibly some invisible oil had entered the boilers in some way, one of the boilers was boiled out with caustic soda, but with no effect.

The opinions of several boiler experts were obtained, but they differed and were unsatisfactory. One thought that the workmanship was poor, another that the design was the worst he had ever seen. Another thought that the tube plates were too limber, and even recommended riveting crown-bars to them to stiffen them.

Spring Hill coal from Nova Scotia was used at first, followed by New River coal from West Virginia. With the Spring Hill coal the lower ends of the tubes quickly became incrusted with clinker, and were finally closed by it, and a little later the clinker would hang in stalactites from the tube ends. Not all of the ends would be closed, but this was the case with a large proportion of them. With New River coal there was less trouble. Spring Hill coal was satisfactory under horizontal boilers, and never plastered over the tubes; in the vertical boilers, however, the incrustation was so hard that it had to be removed with chisels. This incrustation was, of course, molten earthy matter, injected by the draft against the tubes and tube plate, and there congealed by the comparatively low temperature of the metal. In the horizontal boilers it falls to the bottom of the setting before it arrives at the tubes. In watertube boilers it can be seen adhering to the lower tubes.

The existence of this incrustation probably furnishes the explanation of the tube leakage. As a large proportion of the tubes became stopped up the others had to pass all the hot gases, the water about their ends was probably driven away, and they became very much overheated, causing them to over-expand, to become upset, and at some later time, when they became cooler, to be loose in the holes.

As a last resort, when it seemed as if the boilers must be consigned to the scrap heap, some one suggested that to lengthen the fire-box, and raise the boilers by the amount of the extension, might cure the trouble. One boiler was thus altered, started Aug. 31, 1908, and run at the estimated rate of 1,100 horsepower twenty-four hours per day for some three months, without the slightest leakage, although the tubes were very thin from over-expansion. The other boiler was then altered, and started Feb. 25, 1909. When the first boiler was worked at the estimated rate of 1,100 horsepower, it consumed 84,000 pounds of New River coal in twenty-four hours, burning it at the rate of 46 pounds per square foot of grate per hour. Neither boiler has leaked up to the time of presenting this paper.

The distance from the grate to the tube-plate is now 12 feet 2¾ inches. There is some incrustation, but it is light, brittle and easily crushed, and can be blown off by a rotating multiple-tube blower in the smoke-box. The tubes are conveniently and quickly blown in this way every three or four hours.

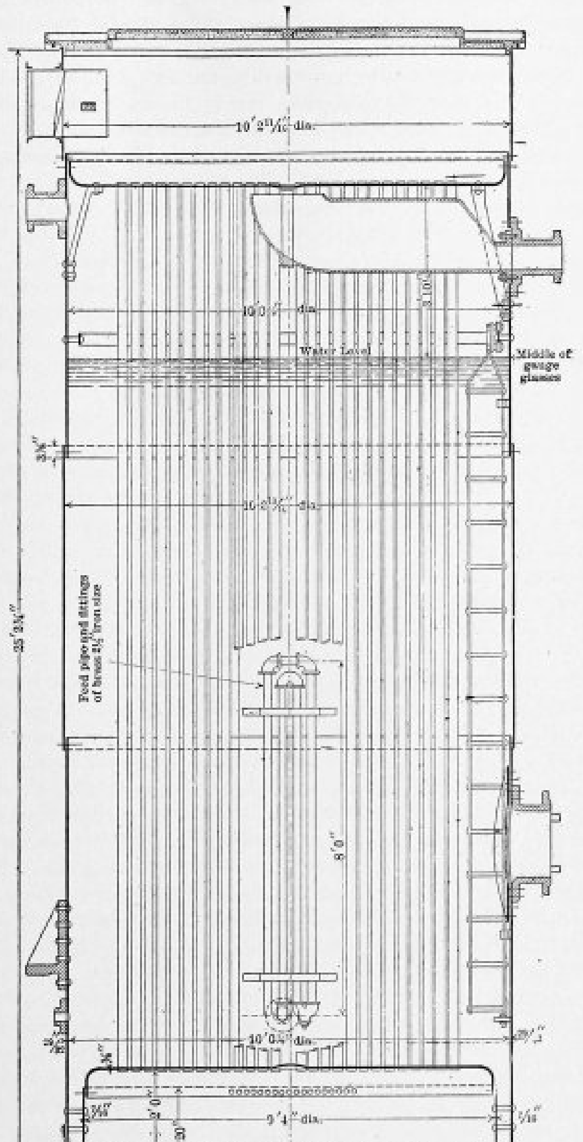
The boiler plant at this mill consists of Babcock & Wilcox

* To be presented at a meeting of the American Society of Mechanical Engineers.

boilers, 90-inch horizontal return tubular boilers, and the two vertical boilers described. The latter were intended to reduce the space occupied, both on the floor and above. The rear drum of the chain grate is exposed, and the clinker is dropped at the back end, where it is easily removed without inconvenience to the fireman. Above is room for the smoke flues and economizer, which with other types of boiler would have been placed, in this case, with difficulty.

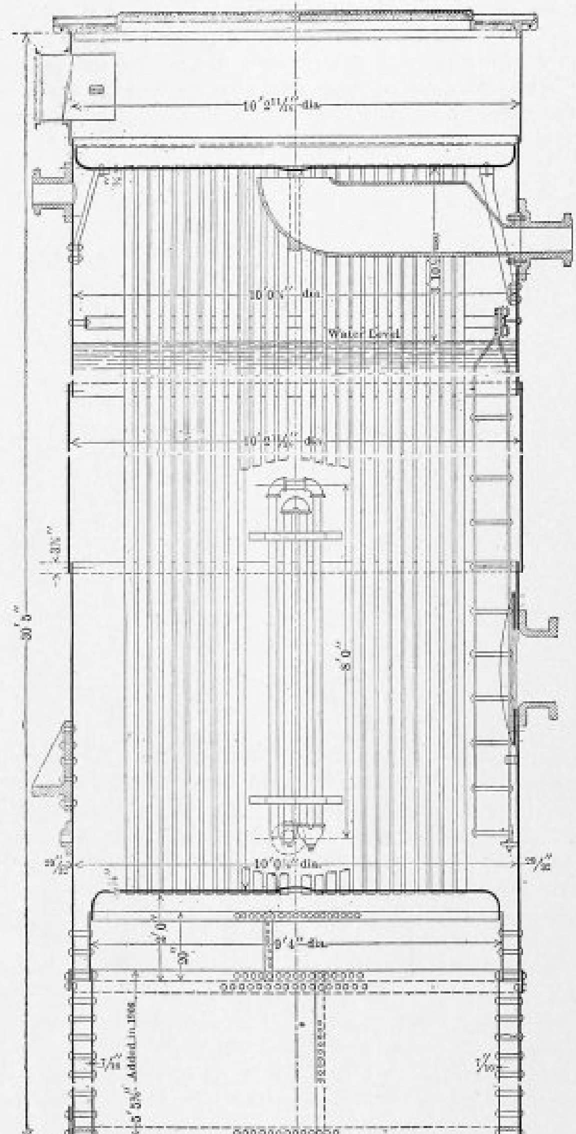
do not know. Experiments will probably be made to ascertain this and overcome the trouble. It might disappear with another kind of stoker.

That the boiler efficiency was good is evident from the low temperature of the escaping gases, when developing over 1,000 horsepower, which is at the rate of less than 5 square feet of water surface per horsepower. The evaporation was best on combustion when the boiler was operated at double its rated



BEFORE ALTERATION

FIG. 1.



AFTER ALTERATION

FIG. 2.

After these boilers had been operated long enough to show that they were reliable and a good investment, it was decided to test one of them.

While the evaporation is good it is not satisfactory. The function of a boiler is to absorb the heat generated in a furnace. The furnace efficiency may be poor and the boiler efficiency good, and that was the case during these trials. The best furnace result occurs when the carbon is burned to CO_2, with as little surplus air as practicable. In these trials the CO_2 was low, and some CO was nearly always found. It was impossible to get any better combustion, for reasons which I

horsepower. It was found impossible to keep the horsepower down to 500. This could only be done by reducing the grate area.

An interesting result of the tests is that the superheat was the same at all rates of power.

Returning again to the matter of clinker on tubes, it occurs on locomotives which burn anthracite coal, and I understand on locomotives of the Boston & Maine Railroad that burn coke. In the latter case, coke-burning locomotives cannot be used on long runs, but whether a better quality of coke would be more successful I do not know. Professor Denton has informed me that clinker accumulated on the boiler tubes of a trans-Atlantic steamship on which he was a passenger to such an extent that men were sent into the combustion chambers to remove it. He also referred to a Manning boiler on which this trouble occurred.

Method of Laying Out the True Camber of a Taper Course.

I herewith submit to the readers of THE BOILER MAKER a rule for laying out the true camber of a regular tapering course whose radii are very large. This rule, no doubt, will be new to many, but is quite simple, and will be found to be very accurate, more so than any other method I have used, except when the camber has been drawn from a center or apex.

Having determined the sine of the angle, refer to a table of natural sines and find the degrees and minutes corresponding to same. Mark the degrees off on the arcs and draw radial lines to *A* and *H*. Space the same off in equal lines to *A* and *H*; letter the same so that corresponding letters will not be opposite each other, as noted on the sketch. The points at which each line of corresponding letters cross will be a point through which the camber will pass, as noted by *PPP*.

Draw radial lines *L L*, on which lay off the distance from *P* to P_1, equal to the slant height of the course. Passing a curve through the points *P*, *P* from *O*, as a center, will convince the reader that this is a very accurate method. To further demonstrate the accuracy of the foregoing method, I have, in Fig. 2, produced a semi-circle by the use of the method involved in laying out the camber of a cone sheet.

J. N. HELTZEL.

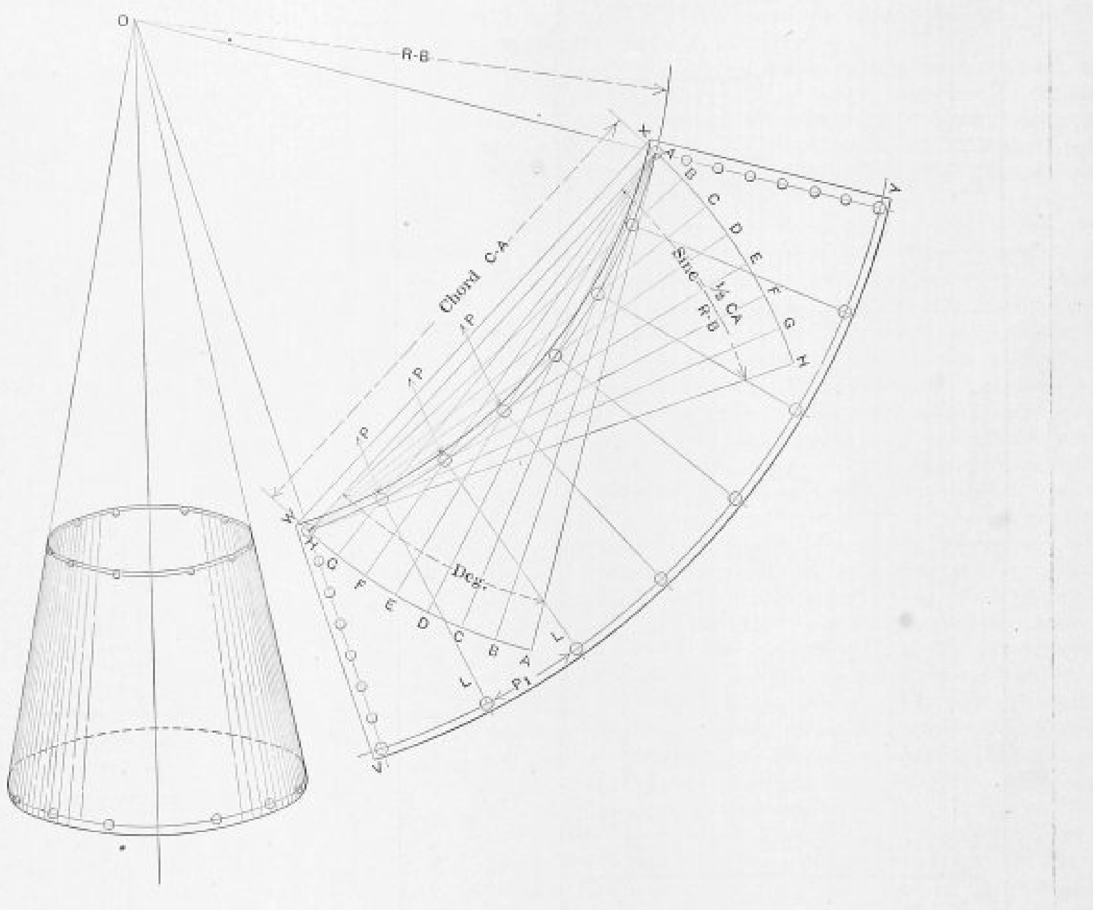


FIG. 1.

For an illustration, *V*, *W*, *X*, *Y* (Fig. 1) represents a very large sketch plate, as it is ordered from the mill. We know the radius *R B* and the chord *C A*. Rules for calculating these are described in my article on "A Self-Supporting Steel Stack Base," published elsewhere in this issue.

Use the chord *C A* as a radius and scribe an arc, *A H* and *H A*, using *A* and *H* as centers, preferably at the small end of the sheet, as it allows the diagram of radial lines to be constructed on the sheet; whereas, if the larger camber is drawn by this method the diagram will extend beyond the extremes of the sheet, which will be quite unhandy for the layer-out. We will then find the degrees in the arc *H A* and *A H*, which are the same.

$$\text{The sine of the angle is } \frac{\tfrac{1}{2}\, C\, A}{R\, B}.$$

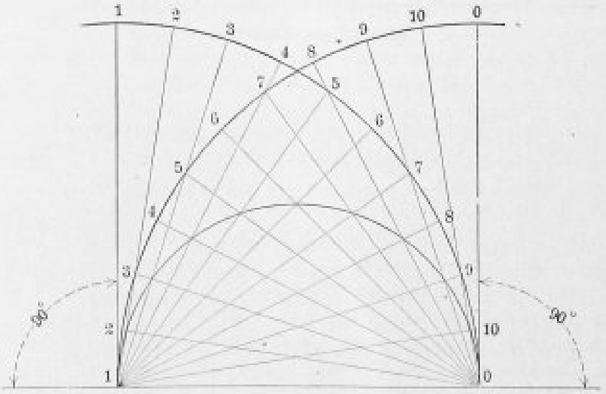


FIG. 2.

THE BEST FORM OF LONGITUDINAL JOINT FOR BOILERS.*

BY F. W. DEAN.

It has been generally accepted in this country for a number of years, that the best form of butted longitudinal-riveted joint for boilers is that in which the inside strap is wider than the outside, and has one or more rows of rivets which pass through the shell and the inside strap beyond each edge of the outside strap. The pitch of the first row of outer rivets is double that of the rows that pass through both straps, and if there are other outer rows they may or may not have a still greater pitch.

In England, where, until comparatively recently, boiler construction has been superior to ours, this form of joint appears to receive no recognition. It was first devised, as far as I know, by Dr. E. D. Leavitt, past-president of the society, and Edward Kendall, both of Cambridge, Mass., and was first used by Mr. Leavitt in some locomotive-type boilers designed by him for the Calumet & Hecla Mining Company. I have a blue print of this boiler dated 1879. It is, of course, hazardous to state that this joint was never used before, and it is quite possible that it was used in England, discarded and forgotten as poor construction, as I believe it is. It was first used on an American locomotive by the Baldwin Locomotive Works in a consolidation locomotive built by them for the Calumet & Hecla Mining Company, the drawing of this joint having been made by me when I was in Leavitt's employ.

While every boiler maker has for years been familiar with butt joints, this form made slow progress towards adoption in this country. One form of joint used to avoid the butt joint and get something as good was a lap joint with an inside strap bent at the edge of the lap and riveted on each side of it. This was used on locomotives exclusively, and was of little or no value, as it was simply a somewhat elastic bent tie connecting the two parts of the shell plate. Finally, and fortunately, this joint gave way to the butt joint first described.

I believe there has been no case of an explosion of a butt-joint boiler; at least one due to rupture of the joint. Recently, however, a boiler at Woonsocket, R. I., narrowly escaped explosion, a longitudinal rupture of the plate on one side of the joint, and within its limits, being discovered while the boiler was subjected to steam pressure. The steam pressure was rapidly reduced and no explosion occurred. An account of this is given in *Power*, Jan. 26, 1909, and the joint itself is in possession of the boiler inspection department of the Massachusetts district police at the State House in Boston.

It has been growing upon me for some years that a one-sided boiler joint, such as that first described, is poor construction, and may sooner or later cause a crack in the plate. The Woonsocket phenomenon has tended to confirm this opinion. It is evident that unless the outside rivets fill the holes they do very little good, and when they do fill them they form an over-hung connection, and to some extent possess in themselves the now recognized defect of the lap joint. Moreover, the extended inside plate forms a bent connection between the different rivets at different distances from the center line of the joint.

In many cases designers have placed the outside rivets at a considerable distance from the edge of the outside strap, and this is constantly overdone. It is obvious, on careful thought, that the outside rivets should be as near the edge of the outside strap as practicable, thereby diminishing the bent-tie effect. In order to diminish this effect still further, and also to render the over-hung rivets more effective, the inside strap should be thicker than usual, and this feature can hardly be overdone. The inside strap should be at least as thick as the shell plate, and great care should be taken to have the holes match and the rivets fill the holes.

When a joint of this kind is tested to destruction in a testing machine, it will be found to fail somewhat in detail, the inside strap bending slightly and the outside rivets being the last to rupture after yielding a little. In a boiler the joint would be weaker than a flat specimen on account of the bent-tie feature. This could be prevented if it were practicable to calk the inside strap, as it would thereby be compelled to maintain the circular form. The theoretical efficiency of this joint is greater than of any other kind, but in practice I believe the efficiency is not realized, and the defects that I have described render the joint, in my opinion, undesirable.

In order to avoid the defects of the one-sided butt joint, I have adopted and intend to use hereafter a joint with both straps of the same width, as illustrated in Fig. 1. This has the merit of having all rivets in double shear and the strains all taken care of in the best manner. The efficiency of this joint can hardly be above 84 or 85 percent, while that of the one-sided joint can be theoretically 91 or 92 percent; but the certainty that the efficiency of the former is realized in practice is ample compensation for the use of slightly thicker plates. The pitch of the outer rows of rivets is rather great, compelling the use of a thick outside strap in order to stand calking and remain steam-tight. I use an equally thick inside strap in order to diminish the bent-tie effect. This effect is small, however, as the rivets are all near the center of the joint. It can be eliminated by calking the inside strap, which is practicable with this joint, and is done in the best marine practice. This assumes that the calking is effective and remains so.

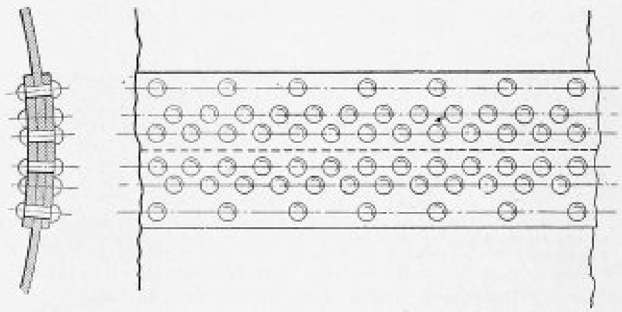


FIG. 1.

While upon this subject it is well to call attention to the perfection with which the longitudinal joints of boiler-plate cylinders can be welded, as has been demonstrated for many years with corrugated furnaces and more recently with soda digesters. While the joints of corrugated furnaces are in compression those of digesters are in tension, and their proved safety should be sufficient to overcome any timidity concerning the perfection and safety of welded joints. Circumferential are not so easily welded as longitudinal joints, and it is, of course, of little importance in boilers that they should be welded.

* To be presented at a meeting of the American Society of Mechanical Engineers.

The Shearing Stress in a Rivet.

The shearing stress in a rivet increases from nothing at either of its ends and at the center of its length to a maximum at the plane of shear. In this plane it is greatest at the center of the rivet, falling off in a parabolic curve towards the circumference. The maximum shearing stress in the center is therefore about double the mean.

The Boiler Maker

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CIRCULATION STATEMENT.

Our aim in circulation is quality, not quantity. We guarantee that we have subscribers in nearly all of the railway, contract and marine boiler shops in North America, as well as in many of the leading boiler shops in other parts of the world, and that nearly every subscriber is either an owner, manager, superintendent, foreman or layer-out. Our subscription books are always open for inspection.

NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

Proposed Boiler Legislation for Detroit.

We desire to give our hearty endorsement of the ordinance, which has recently been introduced in the common council of the city of Detroit, to provide for and regulate the operation and inspection of steam boilers. This ordinance is patterned after the Massachusetts law, and in it are incorporated the present Massachusetts rules for the construction of boilers. Provision is made for the appointment of a board of boiler rules, consisting of four members, including a mechanical engineer, a boiler manufacturer, an operating stationary engineer, and a steam user who, together with the boiler inspector, shall be qualified to hear all complaints arising under the provisions of the ordinance, and to recommend from time to time such amendments to the boiler rules as are deemed advisable to correspond with the best modern practice. With such an admirable basis as the Massachusetts rules, and with ample provision for change of the rules when necessary to conform to modern requirements, this ordinance deserves the hearty support of the citizens of Detroit. It already has the unqualified approval of all who are in favor of adequate boiler legislation in our cities and States, and we sincerely hope that it will soon become a law, and that other cities will follow Detroit's example in this matter.

Admirable as the ordinance is, there is one criticism which we cannot refrain from making, and that is regarding the provision for the qualifications of the chief boiler inspector and his assistants. The ordinance states that the chief inspector must be a man of skill, and of at least ten years' experience in the operation of steam boilers, etc. There shall also be a chief assistant inspector and such other assistants as the common council and the board of estimates shall provide from time to time, one of whom shall be a boiler maker. The chief assistant inspector and all other assistant inspectors, except the boiler-maker assistant, shall be required to have all the qualifications provided for by this ordinance for the boiler inspector. The boiler-maker assistant inspector shall be a competent and practical boiler maker of not less than ten years' experience in such trade.

It will be seen from this that boiler makers are shut out entirely from the opportunity of obtaining a position as chief boiler inspector, or assistant chief inspector, and, further, that only one boiler maker can be on the city pay roll as inspector at one time, and that in no way, except by obtaining the necessary ten years' experience in the practical operation of boilers, can he become eligible for the position of chief inspector, or assistant chief inspector. We believe that this narrows the qualifications of the inspectors too much, and will tend to shut out from office competent men, who might possess superior qualifications to those which are made essential requirements in the ordinance.

So far as we have ever been able to discover, boiler makers, provided they have the proper qualifications, make as good, if not better, inspectors than operating engineers, and we believe that the position of the chief boiler inspector and assistant chief inspector should be open to competent boiler makers. We do not take this stand entirely from the point of view of the boiler maker, but from the point of view of the citizens of Detroit, who are depriving themselves of the opportunity of utilizing some of the best qualified men for this important position.

The Proper Form of Longitudinal Seams for Steam Boilers.

Mr. Dean's declaration that he is going to abandon a form or longitudinal joint for steam boilers which theoretically has a very high efficiency, for one of decidedly less efficiency in the interests of safety, is commendable, if the reasons for doing this are sound. Mr. Dean's wide range of experience and observation in the steam boiler field naturally entitle him to speak with considerable authority. But it is likely that his arguments against the common double butt strap joint, in which the inner strap is wider than the outer by a sufficient amount to take a single row of widely-spaced rivets, will arouse considerable opposition.

The form of joint which Mr. Dean recommends is as nearly symmetrical as any joint in a curved surface can be. The width of straps and number and spacing of rivets on either side of the joining edges of the shell plates are the same, and the bent-tie effect, which Mr. Dean deprecates so heartily, is reduced to a minimum.

We are inclined to believe that the question of good workmanship has sufficient influence on any design of riveted joint to make it either satisfactory or universally condemned. With good workmanship, then, the old style of joint is still likely to be retained by many able boiler makers.

PERSONAL.

John Cook, formerly of Springfield, Ill., has taken charge of the Tulsa Boiler & Sheet Iron Works, Tulsa, Okla.

R. E. Howe recently resigned his position as foreman boiler maker of the Rutland Railroad, at Rutland, Vt., to accept a position with the General Electric Company, in Schenectady, N. Y., as assistant foreman of the blacksmith shop, in charge of boiler and tank work.

W. E. O'Connor has accepted a position as layer-out for the Erie Railroad at Hornell, N. Y.

H. Dustin has been made master boiler maker of the Southern Pacific at Oakland, Cal.

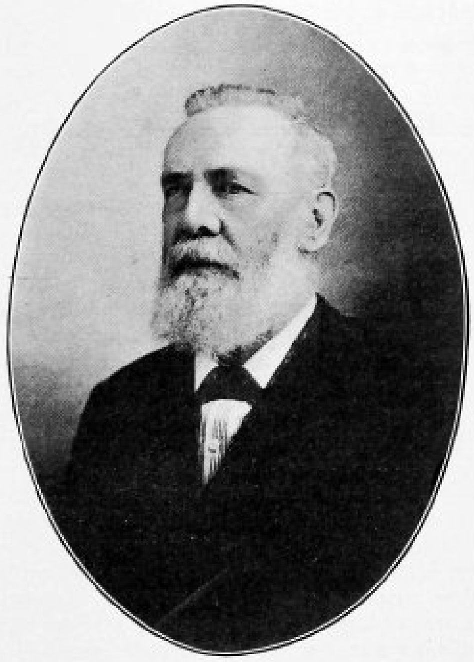
William Lawler has resigned as master boiler maker of the Oregon Short Line at Pocatello, Ida., and has been succeeded by Mr. P. J. Heron.

Frank McKeon has been appointed master boiler maker of the 'Frisco shops at Sapulpa, Okla.

Mr. W. M. Wilson, formerly president of the Master Steam Boiler Makers' Association, has resigned as general foreman boiler maker of the El Paso & Southwestern Railroad, to take the position of general foreman boiler maker at the shops of the Chicago, Rock Island & Pacific Railroad, at Silvis, Ill.

D. M. Chaisson, formerly general foreman boiler maker of the Central Vermont Railroad, is now foreman of the Northern Railway Company, San Jose, Costa Rica, Central America. Up to four years ago Mr. Chaisson was general foreman boiler maker of the Boston & Albany Railroad shops at Allston, Mass.

Isaac Barton.



ISAAC BARTON.

Isaac Barton, vice-president of the E. Keeler Company, Williamsport, Pa., was the recipient of congratulations from hosts of admiring friends on Oct. 1, the occasion being a double anniversary, of which Mr. Barton, the members of the firm, their hundreds of employees and the people of Williamsport were all justly proud. Fifty years ago, on Oct. 1, Mr. Barton first entered a boiler shop, and forty-five years ago, on the same date, he branched out as a manufacturer of boilers. Mr. Barton has been identified continuously with the boiler-making industry from the first day of his apprenticeship to the present time, either making boilers or conducting the business of a boiler-making establishment.

Mr. Barton learned his trade at the boiler shop of Thomas, Carson & West, Norristown, Pa., a firm which is no longer in existence. After serving his apprenticeship he left Norristown and worked at his trade in various shops throughout the country. In 1864 he was employed at the Dickson Works in Scranton, Pa., where at the same time William B. Maitland and Joseph Heathcote were also employed. A strong friendship sprang up between these three men, and the outcome of it was that they decided to start a boiler shop in Williamsport. The firm began business under the name of J. Heathcote & Company, a title which in 1878 gave way to that of E. Keeler Company.

Although Mr. Barton is vice-president of the concern and in his seventy-second year, yet he takes a very active part in conducting the manufacturing end of the business, and twice each day makes the rounds of the big shop, keeping in touch with every department and piece of work turned out. Several foremen and their assistants and a large force of men are directly under his supervision. Although handicapped by defective eyesight for forty years, he has accomplished a great deal more than many men who have perfect vision. One rule which he has always kept, and which no doubt has been a strong factor in his success, is promptness. He has been at the shop every morning for forty-five years at 6 o'clock, and never until this year has he taken a vacation.

It is largely due to the efforts of this veteran boiler maker that the E. Keeler Company has had such a tremendous growth. This company is one of the largest boiler-making concerns in the country, and has turned out many large orders for export to Europe, Africa, Asia and Australia. Just at present a new shop, 162 feet by 100 feet, is being erected on adjoining property, to be devoted to sheet-iron work, and to allow more room in the old shop for the manufacture of watertube boilers, a department of the business which, due to its constant increase, has become cramped for room.

COMMUNICATIONS.

Design of a Vacuum Tank.

Editor The Boiler Maker:

I should be glad to have some of the readers of The Boiler Maker give some information regarding the design of a vacuum tank. What thickness of material should be used in the shell and head of a vacuum tank 7 feet diameter by 13 feet long to withstand a vacuum of 28 inches? Also what is the best means of reinforcing such a tank?

Vacuum.

Concerning Various Matters Recently Discussed in The Boiler Maker.

Editor The Boiler Maker:

I inclose a local newspaper clipping which will, perhaps, show why such ignorant engineers as described by Mr. Holloway in your September number are employed in the oil fields:

> WANTED.—Irrigator, $45, found; farm hands and teamsters, $35, found; lumber piler, $40, found; car repairer, $60, found; dish washer, $35, found; engineer, $35, found; stable hand, $30, found, etc.

You will note that farm hands, teamsters, and even dish washers are rated the same as an engineer, and that a lumber piler is rated a little higher. What can be expected under these conditions? It is all right for Mr. Holloway to ridicule the ignorance of the engineer, but what about the owner of the boiler? The engineer cannot be blamed for attempting to hold his position if the boiler owner will employ him, and it seems to me that the owner is far more to blame than the engineer.

Regarding your recent editorial on government inspection of locomotive boilers, I beg to differ with you regarding the statement that locomotive boilers are rigidly inspected. In *The Locomotive* for January, 1909, under "Boiler Accidents" listed for the period from August to December, 1908, there are 28 explosions of locomotive boilers, but only four of marine boilers, or seven times as many boilers exploded under inspection by railroad companies as did under government inspection. It seems very evident that locomotive boilers are none too rigidly inspected, and that government inspection of locomotive boilers would be a very good thing.

It is high time that a bold stand is made for a better educated class of workmen in the boiler-making trade. The technical and scientific details of boiler making should be studied by foremen and others, more than the methods of driving their men to get the most work out of them. How many foremen or inspectors can be found who are competent to figure the percentage strength of riveted joints, or even the safe working pressure of a boiler? Looking through the list of master mechanics and superintendents of motive power, or even general foremen, it is remarkable how few boiler makers are found among them. They are nearly all machinists, and yet the boiler is beyond any argument the most vital part of a locomotive. The means for gaining technical knowledge are now so many, and so easily accessible, that there is little excuse for anyone neglecting them, and promotions from the ranks of boiler makers should be as frequent as is the case in other branches.

F. F. Z.

TECHNICAL PUBLICATION.

Welding and Cutting Metals by Aid of Gases or Electricity. By Dr. L. Groth. Size, 5½ by 8¾ inches. Pages, 281. Figures, 124. New York, 1909: D. Van Nostrand Company. Price $3, net.

Those of our readers who have become interested in the various articles which we have published recently regarding oxy-acetylene welding will find this book of value, largely because in it have been brought together most of the information which is to-day available regarding the various processes of welding, among which, of course, autogenous welding has a prominent place. The author states in the preface that recent investigation has shown that welding is being used to a far greater extent than is generally known. We can well believe this since learning to what extent it is used in this country alone. Moreover, it is a form of work which is bound to be used more and more widely as it becomes better known.

The first chapters are confined to general remarks on the subject of welding, and a description of the various gases used, and the source of their generation. The next chapter includes a brief statement of the many various methods of welding, the more important of which are amplified in the following chapters. Since welding and cutting metals by gases can only be accomplished by means of blow pipes, these important instruments are described in detail before taking up a description of the actual methods of welding.

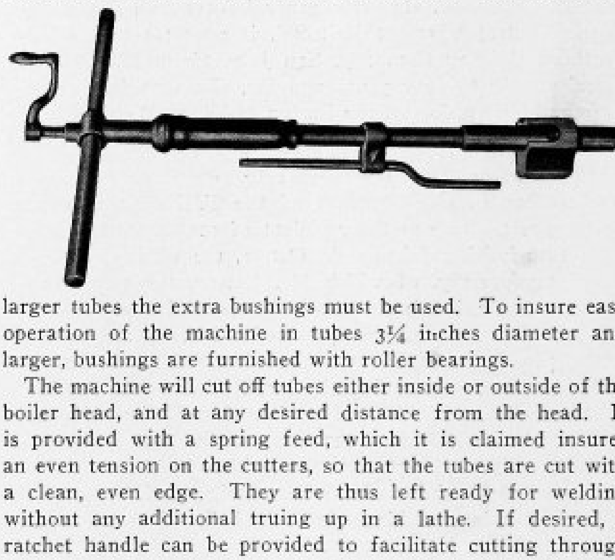
Two chapters which will be of particular interest to boiler makers are those on the welding of sheet iron and welding applied to steam boilers. From the former, one is impressed at once with the wide range of adaptability of welding to modern manufacturing processes. The latter is confined principally to a discussion of what has been done in boiler welding, and the advantages and disadvantages of this form of work. Naturally much of the subject-matter is made up from articles previously published in current engineering literature, and it is to be regretted that the author did not give fuller credit to the publications from which he obtained this material. Included in it are two editorials from recent issues of THE BOILER MAKER, besides abstracts of other articles which we have published, and only meager credit is given to us as the source of the material.

This book should prove a valuable addition to the library of any boiler maker who is interested in modern methods and possibilities of improvement in present-day construction.

ENGINEERING SPECIALTIES.

Wernicke Boiler Tube Cutter.

The Wernicke boiler tube cutter, which has recently been placed on the market by Joseph T. Ryerson & Son, Chicago, Ill., is so constructed that with one-size tool any size tube from 1¾ up to 4 inches in diameter may be cut off. This is accomplished by attaching various-sized bushings on the cutter end of the machine, so as to bring the cutting wheels out in contact with the inside of the tube to be cut. The machine is regularly furnished for cutting off 1¾-inch tubes, and for

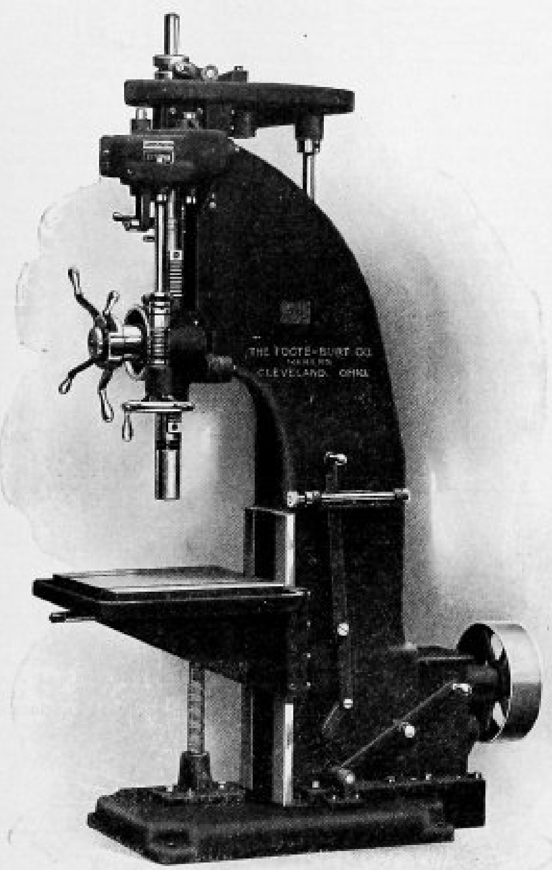


larger tubes the extra bushings must be used. To insure easy operation of the machine in tubes 3¼ inches diameter and larger, bushings are furnished with roller bearings.

The machine will cut off tubes either inside or outside of the boiler head, and at any desired distance from the head. It is provided with a spring feed, which it is claimed insures an even tension on the cutters, so that the tubes are cut with a clean, even edge. They are thus left ready for welding without any additional truing up in a lathe. If desired, a ratchet handle can be provided to facilitate cutting through the larger-sized tubes, and it is also possible, by purchasing an expander attachment, to use the machine as a flue expander on tubes up to 3 inches diameter. Each machine is provided with an adjustable gage to regulate the distance the tubes are to be cut off, so that all tubes may be cut off the same length. The machine is made of first-class material throughout, and is claimed to be very rapid in operation.

The Foote Burt No. 24 High Duty Drill.

This machine has a capacity for high-speed drills from ½ inch to 1¾ inches in solid steel to their full cutting-edge capacity. It is single-belt driven, and all speed and feed changes are through a quick-change gear device of special design. Levers for stopping and starting the machine and for changing feeds and speeds are all conveniently located, and within easy reach of the operator at all times. Spur gears are used throughout, except one pair of slow-running two to one bevel gears at the driving end and one worm and worm gear for the feed. The spindle is of forged high carbon steel, fitted with ball-bearing thrust. Three changes of geared feed are provided; any one of which is instantly available by simply shifting a lever, conveniently located at the front of the machine. Power feed is provided with an adjustable automatic stop and hand stop. Hand feed is through a worm and worm gearing, and quick traverse of the spindle in either direction is accomplished through a spider hand wheel, located at the front of the machine, which, with either the in or out movement of any or all the handles, engages or disengages the same. The table is of the bracket knee type, having a large, square, lock-bearing surface on the upright, to which it is securely gibbed. It is further supported and elevated by a square-thread jack screw, located underneath, slightly back of the center of the spindle, to permit boring bars or other tools passing through the table. The drive is a self-contained

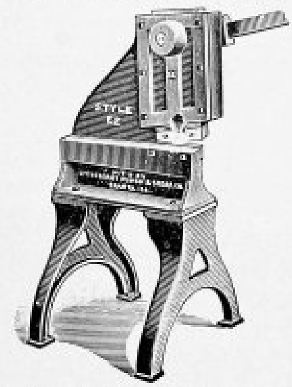


unit, neatly located in base of the machine. The nine spindle speeds are through a double train of gearing, which is always in mesh and runs in a bath of oil. This device consists of a lock bolt engaging any one of three gears in each of the two trains, giving the nine speeds, any one of which is instantly available by shifting the levers. One pair of two to one bevel gears are securely housed at the end of speed box, inside of column, which make the connection to the vertical driving shaft. The distance between the vertical driving-shaft gear and the spindle gear, being spanned by an idler spur gear, overcomes the necessity of more than one pair of bevels in the construction of the entire machine. A tapping attachment can be furnished when so desired, consisting of a positive steel clutch, located on the idler gear at the top of the machine. This attachment reverses at the ratio of two to one.

This drill, which is so well suited for the heavy work required in a boiler shop, is manufactured by the Foote-Burt Company, Cleveland, Ohio.

The Little Giant Splitting Shear.

The splitting shear illustrated was designed by the Little Giant Punch & Shear Company, Sparta, Ill., to split sheets of any length and with up to 3/16 inch thickness. The shear plunger is actuated by a pintle or link movement, with eccentric shaft of sufficient diameter and strength to give the necessary power and efficiency. The plunger is large and accurately planed and fitted, the wide bearing insuring proper alinement of the shearing blades under all conditions. The face plate is accurately bored and fitted to the shaft. The



machine is fitted with an adjustable hold-down to prevent the material from rising while being cut. The lever works from the front of the machine and is adjustable, so the travel can be shortened when dong light work. Sufficient clearance is given in the body, so that the sheets can pass without binding. Besides splitting sheets up to 3/16 inch thickness, it is claimed that this machine will cut bar iron 3/8 to 2 inches. The shearing blades are 7 inches long, and the adjustable lever 54 inches. The machine is 44 inches high over all, occupies a floor space 23 inches by 23 inches, and weighs 400 pounds.

SELECTED BOILER PATENTS.

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

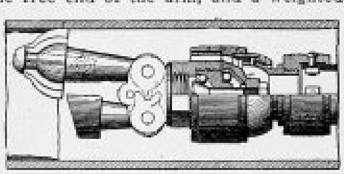
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

932,209. BOILER-FLUE CLEANER. JOHN WIECHMANN, OF ALBANY, N. Y.

Claim 1.—A boiler-flue cleaner having a rotatable cutter head consisting of a frame and a plurality of longitudinally extending rotatable cutters of conical form and provided with lengthwise arranged cutting edges notched transversely along a spiral line, the apex ends of the said cutters being forward and pivoted to the frame, and springs supporting the rear end and permitting them to yield inwardly. Seven claims.

932,210. FLUE CLEANER. JOHN WIECHMANN, OF ALBANY, N. Y.

Claim 1.—A flue cleaner having a revoluble cutter head, comprising a body, a cutter arm fulcrumed on the body, a cutter wheel mounted to turn freely on the free end of the arm, and a weighted arm carried by



the body, the weighted arm and the pivoted arm having members engaging with each other. Three claims.

933,909. BOILER-HANGER. CARL E. LINGENFELTER, OF CHICAGO, ILL.

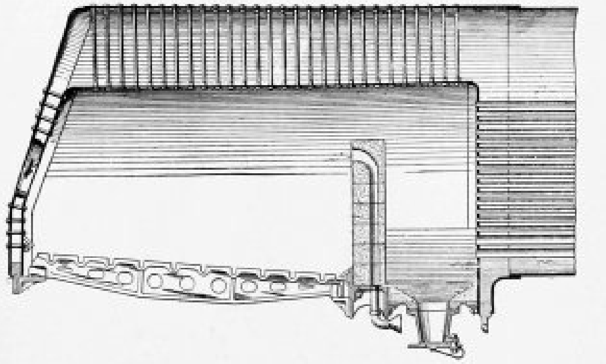
Claim 1.—A boiler-hanger comprising a sheet metal plate bent to form a central projecting portion, U-shaped in horizontal section, widest at its upper end and having vertical walls with inclined side flanges at their inner edges adapted to be secured to the boiler shell, the side walls of said central projecting portion being spaced apart to receive a boiler supporting rod extending therethrough. Five claims.

934,151. SMOKE-BOX SUPERHEATER. MARTIN FISCHER, OF MANNHEIM, GERMANY, ASSIGNOR TO THE FIRM OF HEINRICH LANZ, OF MANNHEIM, GERMANY.

Claim 2.—In combination in the smoke box of a locomotive boiler, two headers arranged one above and below the axis of the boiler, said headers being bent inwardly at their centers toward said axis, two groups of tubes connecting said headers and arranged in an annular space within said smoke box and on opposite sides of the axis of the boiler, the tubes in said groups being arranged concentrically and each tube being zigzagged from the saturated to the superheated steam header. Four claims.

934,157. LOCOMOTIVE-BOILER FURNACE. FREDERICK F. GAINES, OF SAVANNAH, GA.

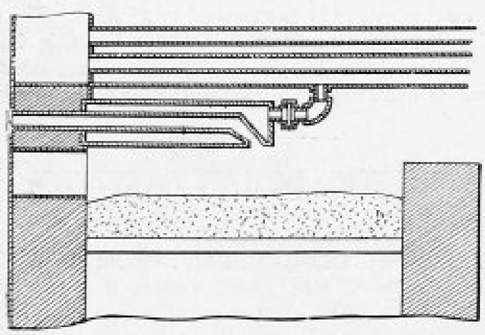
Claim 1.—The combination, with a locomotive boiler fire box having a flue sheet, of a separate and independent bearer extending across the fire box, near the bottom thereof and between the forward end of the grate and the flue sheet, a mud ring, connections securing the ends of



said bearer to the side portions of the mud ring, a bridge wall of refractory material supported on said bearer, a bottom plate closing the space between the bridge wall and the flue sheet, a discharge hopper secured to the bottom plate below a central discharge opening therein, and a movable plate or slide closing the discharge hopper. Six claims.

934,275. DEVICE FOR FEEDING AIR TO FURNACES. ACHILL WALTER BRAND, OF BOISE, IDAHO.

Claim 2.—The combination with a fuel chamber having a front wall of a device for feeding air to the fuel chamber extending through the front wall and to a point within said chamber centrally over the fuel therein, said device diverging outwardly toward the center of the



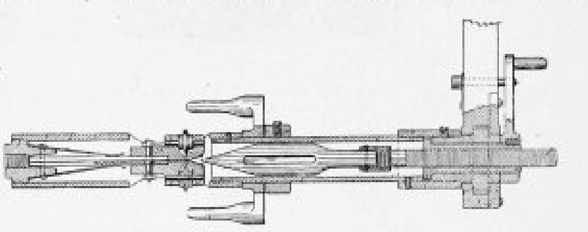
chamber whereby the delivering end thereof extends substantially across the width of the boiler and is adapted to discharge a sheet of air which extends substantially across the fuel chamber, the delivering end of said device being bent downwardly so as to direct a sheet of air downwardly directly on to the center of the fuel, and a water jacket surrounding said device. Two claims.

934,314. BOILER-CLEANER AND FEED-WATER HEATER. ADONIVAM N. JONES, OF WICHITA, KAN.

Claim 1.—In a boiler cleaner, the combination of a boiler, a sediment drum, a partition forming a well within the drum, a stand-pipe arranged within the well, a return pipe leading from the stand-pipe to the bottom of the boiler, means for establishing communication between the drum and the water line of the boiler, and means for drawing off sediment from the drum.

934,351. FLUE-CUTTER. EDWARD M. POPE AND ISIDOR J. B. HANTEN, OF WATERTOWN, S. DAK.

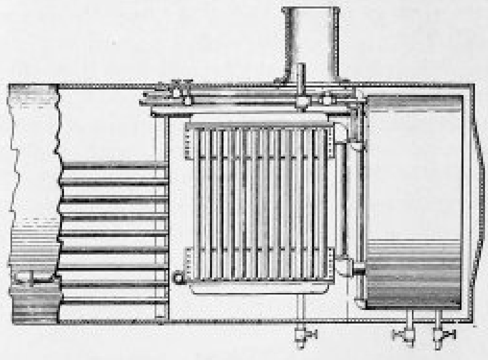
Claim 1.—In a flue cutter, the combination with a tubular body and cutting wheels mounted for radial movements therein, of means for rotating said tubular body comprising a pawl-equipped lever and a ratchet wheel, means for moving said rollers radially outward com-



prising a wedge, a threaded stem, a threaded sleeve, a feed lever ridídly secured to said threaded sleeve and movable therewith, and a device movably mounted on one of said levers and detachably engageable with the other lever, to connect said two levers for common movements, at will. Five claims.

934,393. FEED-WATER HEATER. JOHN WILLIAM CURRIE, OF MINNEAPOLIS, MINN.

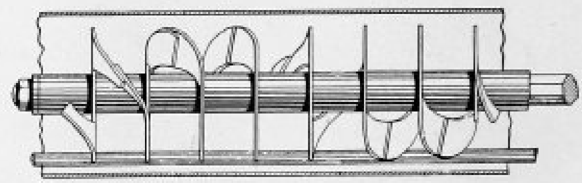
Claim 1.—The combination with a locomotive, of a pair of tube banks located within the smoke box, forwardly of the boiler, said tube banks each consisting of a pair of vertically spaced head plates, a plurality of longitudinally curved pipes engaged at their ends in the head plates, and hollow domes secured upon the head plates, said pipes communicating



with the interiors of the domes, a water feeding mechanism, branch pipes communicating with the feeding mechanism and with the lower domes of the two tube banks, a steam tank located within the smoke box forwardly of the banks, steam circulating pipes communicating with the steam tank and with the boiler, a water tank located within the steam tank, a plurality of tubes extending horizontally through the water tank and communicating with the steam tank, and a water pipe communicating with the water tank and with the boiler. Four claims.

934,572. MEANS FOR FACILITATING THE PRODUCTION OF STEAM. JOSEPH LEON MARIE ALPHONSE REIS, OF ANTWERP, BELGIUM.

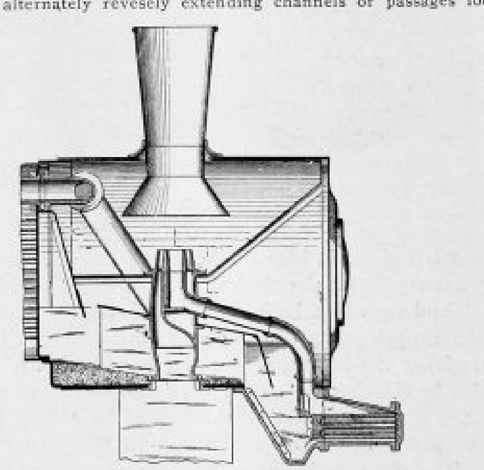
Claim 1.—In a device, in combination, a core rod, a number of disks threaded on said core rod, said disks having openings therein, means



whereby said disks are held at the requisite distance apart, and means whereby the disks are held with their openings at the requisite angle relatively to each other in a circular direction.

934,795. SPARK-ARRESTING APPLIANCE FOR LIGNITE-BURNING LOCOMOTIVES. WILLIAM DALTON, OF SCHENECTADY, N. Y., ASSIGNOR TO AMERICAN LOCOMOTIVE COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

Claim 1.—The combination, with a locomotive boiler, of means for separating the solid and gaseous products of combustion escaping from the boiler tubes, a cooling conduit composed of a plurality of communicating alternately revesely extending channels or passages located



in advance of the forward support of the boiler, said conduit being open at one end to the smoke box of the boiler, a discharge nozzle in the smoke box in which said conduit terminates, and a cylinder exhaust pipe inclosing said discharge nozzle. Eleven claims.

934,718. STEAM BOILER. ELLIS F. EDGAR, OF WOODBRIDGE, N. J.

Claim 1.—A steam boiler comprising upper and lower drums connected by water tubes, all of suitable material and of proper thickness to carry a working pressure of eleven hundred pounds, all of the tube holes in the upper drum having four or more recesses whereby the tubes may be expanded in said recesses to be capable of standing said pressure, the lower ends of said tubes secured to the lower drums, all necessary parts being protected from the heat of the furnace and the water tubes of proper diameter for their lengths, whereby perfect circulation is obtained by the application of heat.

THE BOILER MAKER

DECEMBER, 1909

THE MILWAUKEE BOILER EXPLOSION.

BY R. E. M'NAMARA.

On the morning of Oct. 25 at 4:30 A. M., watertube boilers Nos. 1, 2 and 3 at the Tenth street power house of the Pabst Brewing Company, Milwaukee, exploded with an unusual degree of violence, causing an immediate property damage of over $100,000, and an ultimate loss estimated by Mr. Gustav Pabst to be between $200,000 and $300,000, thus contributing for the year 1909 an aggregate loss due to boiler explosions which has never been equaled during this or any other age.

FIG. 1.—GENERAL VIEW OF THE RUINS.

Fig. 1 gives a general view of the ruins taken the morning after the explosion. Fig. 2 is a closer view of one of the six bursted steam drums, the other five being twisted and distorted fully as much as the one shown. Fig. 3 shows a portion of the wrecked drums on the top of a five-story building some distance away from the scene of the explosion. Some idea of the violence of the explosion may be gained by referring to the elevator shown at the left in Fig. 2. It is a seven-story structure and contained 10,000 bushels of grain. The whole building, however, was moved bodily on its foundation 47 inches.

The immediate cause of the explosion has been variously assigned to a rupture of the main steam line, structural defects, and the other usual universal explanation, low water. Whatever may have been the exact cause, the fact remains that the initial rupture, as far as the steam drums alone are concerned, took place along the rivet line of the reinforcing tube plate, which can be partially seen in Fig. 2. Considering the violence of the explosion and that all six drums let go in practically the same manner, it has been assumed that the

FIG. 2.—ONE OF THE SIX BURSTED STEAM DRUMS.

FIG. 3.—PORTION OF DRUM FOUND ON TOP OF FIVE-STORY BUILDING.

three boilers exploded simultaneously, which further leads to the conclusion that the impulse was probably derived from an outside source, such as the bursting of a main steam line, thus causing a lifting of the water in all three boilers, the resultant reaction tearing the drums longitudinally, as the drums were practically straightened into flat sheets as far as any resemblance to their original shape is concerned; also the twelve 36-inch heads being, in most cases, blown completely out, and the failure of the net section of tube reinforcement plate being practically identical in each case, lends strength to the burst steam-pipe theory, although it may be found, after all the evidence is examined in detail and the fragments collected, that the contributory cause is foreign to the above.

Another explanation, which is entitled to consideration, is the fact that where the thirty-two 4-inch vertical circulating tubes were rolled into the bottom 12-inch round water-leg, the tube ends were in most cases pulled out of their holes, exhibiting, on an average, only a flush bearing, and were not flared at all. If the circulation were very restricted at this point and any local overheating or other unusual cause could be assigned which might start one or more tubes from their seat, the impulse could under favorable conditions have ripped out the remainder of the row, and possibly, although not probably, have caused ultimately through reaction a triple explosion. The low-water question has not even remotely been considered, as the plates or tubes show no evidence of any blue heat.

The boilers themselves which exploded were Nos. 1, 2 and

3 of a battery of four Munoz watertubes, having two 36-inch drums to each boiler, thirty-two 4-inch vertical circulating tubes connecting each steam drum with the water-leg entering the top drum on the bottom center line through a ½ inch by 9-inch reinforcing strip. The inclined watertubes numbered 154 4-inch, and were expanded into sinuous headers, which at front connected with cast steel cross-water boxes or saddles by means of short nipples, the saddles themselves being riveted to and communicating directly with the drums, the watertube spacing being eleven rows high and fourteen rows wide. The drum plates averaged 13/32 inch in thickness, the tees ranging from 55 to 60 thousandths; reduction of area at tear in the net section micrometered from 1/64 to 1/100 of an inch. The longitudinal seams were of the double-butt type, none of which failed. The boilers were but little over two years of age, two 4-inch pops set at 160 pounds being connected to each boiler. The regular working pressure was 155 pounds. Some of the pops were afterwards tested and found to relieve at the stipulated load.

The boiler room after the explosion presented such a tangled mass of steel girders, channel and I-beams, piping, economizer and boiler tubes, breeching sheets, etc., that the task of clearing away the débris appeared hopeless. The streets were also, in places, piled waist high with brickbats and wreckage. It was finally decided that the best and quickest way to remove the twisted mass of steel was by means of the oxy-hydrogen process of cutting metals by fusion, and after installation the work progressed very rapidly, day and night shifts being employed. The work was hurried especially on account of the body of fireman Fred Stein still being under the wreckage. The remains were found three days afterward.

In comparison with past catastrophes, the nearest recent approach, as far as financial loss is concerned, occurred June 15, at the plant of the Denver Gas & Electric Company, Denver, Col., in which, by the explosion of a 400-horsepower Wickes vertical watertube boiler, property and service was damaged to the extent of nearly $100,000. The writer also investigated this accident. Enough time had elapsed, however, for a final collection to be made of all the fragments. The disposition of same proved conclusively that the rupture was due to water hammer, the magnitude of which can hardly be appreciated, even when the fact is stated that the upper section and tubes, weighing over a ton, was projected a vertical distance of more than a quarter of a mile. As regards to loss of life, however, we still have an enormous handicap to overcome if we ever equal or beat the record of the explosion of the starboard boiler of the Mississippi River steamboat *Sultana,* in the year 1865, near Memphis, Tenn. Over 2,000 souls were on board, most of whom were discharged Union soldiers and prisoners of war going home from New Orleans. As can be imagined, the boat was crowded to the bulwarks, there being not much more than standing room. The loss of life, due to this explosion, we are told, approximated 1,300; a large number in addition were also more or less injured.

The Gospel of Efficiency.

True efficiency means ameliorated conditions for the worker, both individually and collectively, not only for the worker, but also for the employer, not only for the employer, but also for the corporation, and, finally, for the nation.

The timid doubters apprehend that increase in efficiency will result in decreased employment. In case of very sudden increase in efficiency there is often temporary dislocation of employment, but there is always ample warning, and, as a result of increased efficiency, it has always proved to be the case that there is more business, not less; more employment, not less.

Where modern efficiency methods have been tried on a large scale, the effect on employment has been carefully studied. Before efficiency was introduced, about 7 percent of the employees dropped out voluntarily each month, some because they knew they deserved better conditions, others for various reasons. It was a constant difficulty to recruit the force to bring it up to a quota. When efficiency methods were introduced, the better men were induced to stay, inferior men were not replaced. The reductions possible from increased efficiency were brought about without laying off or discharge of any worker.

Efficiency is not only not a menace to those who sell their time and skill, but it is the broadest and pleasantest path of escape from retrogression and disaster. The efficient man will have employment urged upon him where the inefficient begs in vain. The efficient corporation will be seeking workmen when the inefficient corporation closes it doors.—Harrington Emerson in *The Engineering Magazine.*

THE LOCOMOTIVE ASHPAN SITUATION.

It has been enacted by those who have the safety and welfare of the railway employee at heart (to say nothing of his vote) that on and after Jan. 1, 1910, all locomotives hauling trains that are engaged in inter-State traffic shall be fitted with ashpans that may be dumped and cleaned without making it necessary for any workman to go beneath the engine or between the rails. Like the provision for the periodical inspection of locomotive boilers this as a good one, though needless, because, as in the case of boiler inspection, the railways have long been doing all that the statute requires, so for many years most new locomotives have been fitted with self-clearing ashpans. Still, the law will do not great harm, and it will show the fire cleaner, as doubtless intended, that his good friend the politician is looking after him, and will add a few more inspectors to be fed at the public crib.

From the standpoint of operation, too, the use of the self-clearing pan is good. Not only does it do away with much disagreeable and difficult work in the case of locomotives, but it lowers the cost of doing the work, and incidentally decreases the amount of dust and dirt that is scattered over the machinery at end of every run, and should, therefore, have some effect on repairs. With the promulgation of the law, of course, a cloud of inventors have arisen, ignorant of what has been done, and still more ignorant of the conditions to be met, and these voluntary helpers have brought forward all manner of contrivances to meet the demand and win the prize which some of them think the Inter-State Commerce Commission has offered for the best device. Like the coupler inventors of two decades ago, these people may be disregarded, and with even more reason because of the advancement in the art.

Speaking broadly, there are two general types of ashpans in use upon American locomotives. One is the shallow, flat pan used beneath the old narrow fire-boxes that drop down between the frames, and are set but a short distance above the top of the rail. The other is the hopper type, in almost universal use, though in many forms, on the heavy, modern locomotive.

In the adaptation of the self-clearing pan the greater difficulty has been found to lie in its application to the shallow pan, though the problem has been solved in a very simple and satisfactory manner.

That the self-clearing pan was possessed of advantages over the ordinary design is shown by the fact that it was introduced more than twenty-five years ago, when the narrow fire-box was the standard. One of the earliest of these designs was that of the folding slat, arranged in a manner similar to a window shutter, where a series of slats pivoted at their ends are connected by an operating rod and moved together. This arrangement was tried upon the Flint & Pere Marquette, also on the Illinois Central, and possibly elsewhere, but owing, probably, to faulty design was discarded, to be revived at a later date and made successful, for it is now in use on the Chesapeake & Ohio, and in a modified form on the Chicago & Eastern Illinois.

Another and still simpler arrangement for cleaning the shallow pan is the use of the steam jet. No change is made in the construction other than the placing of a row of steam jets across one end, from which the ashes are blown out at the other. This is the method that is probably receiving the widest application, and its advantages are at once apparent. It is exceedingly rapid in operation, and requires no change in the standard of pan construction that has been in vogue for a half century or more. Further, with the solid bottom the danger of dropping live coals upon the track and bridges is reduced to a minimum, along with the corresponding damage by fire. It was because of the warping of slats and the scattering of coals that the early attempt to introduce the blind slat construction was abandoned.

Another modification of the shallow pan that complies with the law, but is not self-clearing, is obtained by the use of slides in the vertical sides of the pan. When these are opened the ashes are hoed out by hand in the good, old-fashioned manner, but without requiring that the man should go beneath the engine to do the work.

In some cases the type of bottom used on the hopper pans has been adapted to the shallow pan, and with apparently satisfactory results. One instance of this kind is that of the Pennsylvania lines West, where half-doors, swung from hinges at the sides, are turned up beneath the pan. This construction necessarily requires that the bottom of the pan be a little higher above the rail than is sometimes the case, but where it is applicable it has the advantage of a uniformity of practice on all engines.

In the case of hopper pans the larger number of roads use a simple slide. This has been a standard of practice for so long a time that it is quite natural that it should persist. The old method was to put the slide in and drive it home from beneath the engine. Then, when the engine was to be cleaned, a man went beneath, drove it out, and down came the contents of the hopper. It was a hot, dirty job, accompanied by occasional burns that were sometimes serious. It was a simple mechanical problem to connect a row of these slides of the two or three consecutive hoppers, with rods, attach an operating lever, and arrange to manipulate them from the cab or the side of the engine, and this is just what a large number of roads have done.

To those who are familiar with this old form of a hopper slide it is well known that sticking is one of its characteristics. Unless it is carefully designed it has a propensity to get jammed shut and to warp and twist in a manner that frequently leads to the use of language. And then, when cold weather comes on, ice and snow will gather in its crevices in a manner that renders motion impossible without the application of the persuasive energies of a sledge hammer. It follows from this that if a man is not to be allowed to go beneath the engine to drive a frozen or jammed slide loose, it must be well looked after if it is to be moved by the lever commonly used or even by the air or steam cylinders that are sometimes applied. And it is to avoid this danger of sticking by freezing that a few roads have applied steam pipes to the hoppers to thaw them out.

Next to the slide, in number of applications, comes the flap or swinging door. It is easily operated, and that with a simple mechanism which can be arranged to be worked either from the cab or from the ground beside the engine. Ashes flow out over it, and, barring warping, it closes firmly against the bottom or sides of the pan. It is usually constructed to extend across the hopper, and a single door is used for an opening, but sometimes double doors are used, and these may open longitudinally, as in the case of the Pennsylvania lines West.

A final form of drop is one that was introduced a number of years ago on the New York, Ontario & Western, and has given very satisfactory service. In this the door is carried on inclined hangers, through trunnions cast at the ends, while the operating rod is coupled to another set of trunnions. The movement is such that, at the start, the door drops away from the face of the hopper and then tilts up and takes a position back of it, out of the way, thus leaving the whole area of the opening free and unobstructed. It never freezes shut so that a blow from a hammer on the side of the hopper will not free it. It does not clog or jam, and little or no trouble is experienced with the warping of the plates, as they are of the simplest design.

There are, of course, many other designs in use; some quite complicated in the arrangement of the levers, but they are of limited application, and the types detailed above may be said to cover the great mass of American railway practice. There are some of these minor devices that may be ruled out as not meeting the legal requirements. For example, it will probably be conceded by most that it is the spirit, if not the letter of the law, that not only must it be possible to open the ashpan and draw the ashes, but also to close it after such emptying and put the locomotive back in running condition, without making it necessary for a man to go beneath the engine or between the rails. In some cases simple, lateral slides are used that may be easily pulled open by a man outside the track, but require that he shall get beneath the engine and lean over from 12 inches to 15 inches between the rails in order to replace them. That the arrangement complies with the letter of the law there is little doubt. What the commission will do in this and other similar cases remains to be seen, for there are evidently two points of view that may be taken: One is that of a strict literal interpretation of the law and the other that of its spirit. It is evident that the intention of the framers was to construct a statute to protect workmen from personal injury while engaged in the occupation of dumping and cleaning the ashpans of locomotive engines, and this will probably be the position taken by the commission.

To anyone familiar with mechanisms of this character it is evident that they must be of a very substantial construction, simple in design, not apt to get out of order because of the stresses or heat to which they may be subjected, and easy to manipulate, without liability to clogging either by ashes or by ice. Of all these requirements strength of construction and simplicity of design are the most easily met; but it is quite possible that, in two designs which are nearly identical, one may be very efficient and the other impracticable. Take, for example, the simple slide to close a hopper. If one has free guideways from which the ashes are easily pushed and the other has a pocket or a closed end; the first may work year in and year out without causing trouble, and the other may be jammed at every operation. So in the matter of warping plates; if these are not made of suitable metal, properly ribbed and stiffened, the heat of the ashes will distort and cause them to bind.

As a satisfactory ashpan should not be liable to frequent failure and disablement, it should be strong, simple, easily manipulated and not subject to damage from load, handling or heat. It will be seen that so far as the general types of pans passed in review are concerned, any of them can be made to fulfil the requirements of the law. Whether all the designs that are in use will be found to be satisfactory to the railways using them and to the men inspecting them on behalf of the commission remains to be seen. The prognosis for some of them is not very favorable.—*Railroad Age Gazette.*

A BOILER WASHING TROUGH.

BY C. E. LESTER.

The accompanying sketches show a trough which the writer had designed to overcome many disagreeable features connected with locomotive boiler washing. The design, however, is not entirely original, as it was formulated from a rough trough, in a measure somewhat like this one.

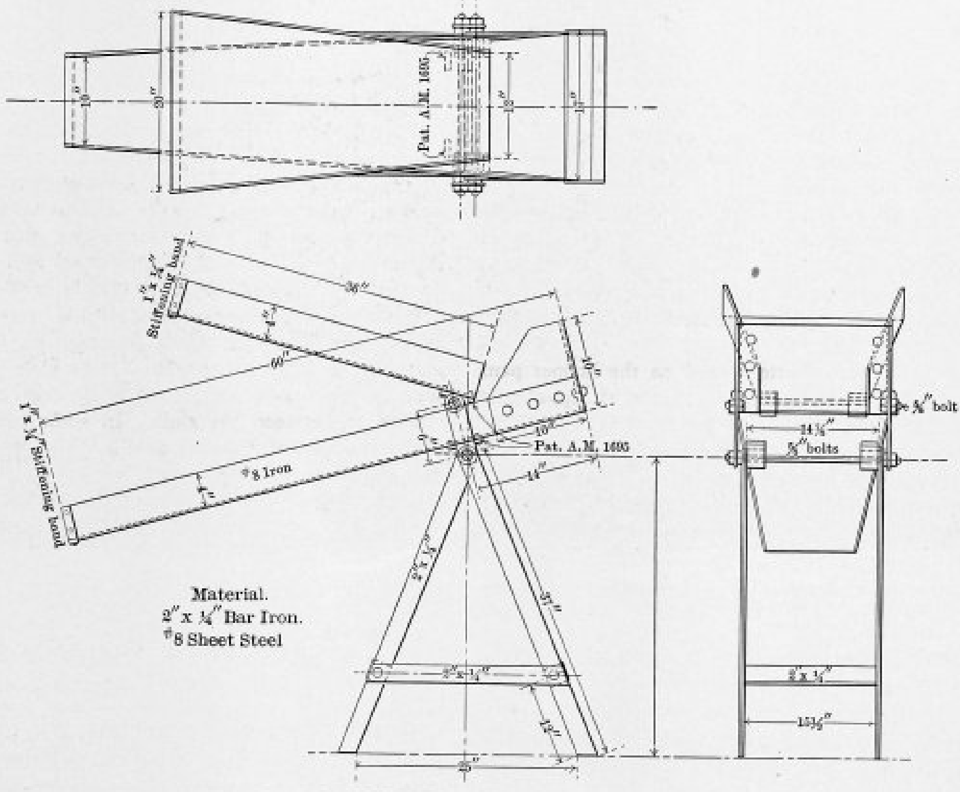
Washing locomotive boilers is, at its best, a very wet and disagreeable piece of work, and is an enemy to shop and roundhouse cleanliness. The washing of wide-type fire-box boilers without some means of disposing of scale, sediment and water keeps the boiler washer and helper wringing wet continually; covers the floor with litter, and fills the rod brasses, driving boxes and eccentrics with foreign matter. The result is that the boiler washer is frequently layed up with rheumatism and kindred ailments, the shop cleaners have more work, and hot boxes, brasses and eccentrics are numerous.

It was to overcome these things that the trough was designed. It is customary at some points to have pits in the roundhouse especially for washout purposes, with perforated plate for flooring for the water to pass through each side of the engine pit, and confine the boiler washing to these pits; however, when pit room is limited, this method does not always work out. Some repair shops require engines in for repairs to be washed out at night, either by the roundhouse gang or by working the day force over-time. This does not always work out well, as the roundhouse gang may not be available, and it is required to pay time and one-half for the over-time for the day gang.

The trough is designed particularly for washing a boiler whose fire-box extends outward over the frames, and it cannot be used on narrow fire-boxes. As will be observed, it is used simply by placing the top end of the upper trough against the mud-ring, immediately under the washout holes at each corner of the fire-box, and the water and sediment will flow from the upper to the lower trough and through that down into the pit.

The total cost of making a set of four of these should not exceed $25, and the money is well spent.

It will be noted that instead of making forgings for the balance or fulcrum blocks, we use a casting AM-1695. This casting is one used regularly in our engine construction and is used for the sake of economy. No doubt, if any railroad man desires to build them, he will find castings suitable among those of his standard castings.



CONSTRUCTION OF BOILER-WASHING TROUGH DESIGNED BY C. E. LESTER.

AN UNUSUAL JOB FOR A BOILER SHOP.

BY JAMES J. FLETCHER.

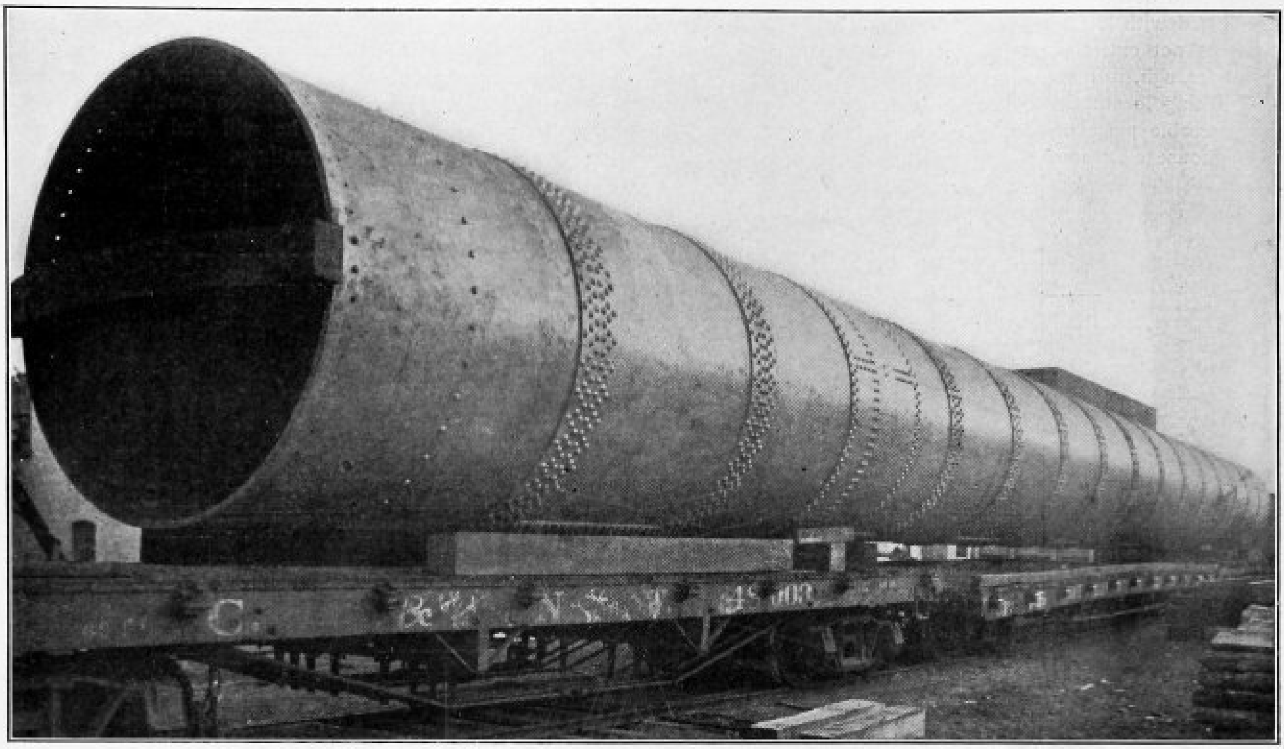
Steel plate work of all kinds is done in boiler shops, from the construction of the smallest vacuum tank to the largest gas holder. Within these limits, however, there are many unusual jobs which come up, such as the one which is shown in the illustration.

This cylinder is 9 feet diameter by 130 feet long, made of ¾-inch plate and butt-strapped circumferentially as well as longitudinally and treble riveted each side of the butt. It is used for a cement burner, and when in use rotates about six revolutions per minute. There are two heavy cast steel riding rings near each end of the cylinder, which are not shown on the photograph, simply because the cylinder could not be shipped with them on, as they would extend too far over the cars, and the railroads would not carry it. These steel riding rings are fastened to the shell with 1-inch rivets, and ride in rolls, which are placed under riding ring and also run alongside the ring. These rolls keep the kiln in position. There is also a sprocket casting on the kiln, which is also not shown on the photograph on account of its diameter for shipping. This sprocket wheel is attached so as to allow an endless chain to run from another sprocket, which is attached to a jack shaft and pulleys, which is again belted to an engine to make the shell revolve. You will note that this large tube is on three cars for shipping. It was necessary to make special saddles to set the pipe into, and they were made to swivel, so as to allow the cars and pipe to turn curves, the center car acting only as an idler. This had to be a special car ordered from St. Louis. This car was 60 feet long. The two end cars were 40 feet long, having a capacity of 200,000 pounds. This was essential in order to carry the weight of pipe, which weighed nearly 100 tons.

This pipe was made for the Chalmers & Williams Manufacturing Company, of Chicago Heights, which has contracted for the whole of the machinery for a large cement company in Missouri. A second kiln of the same dimensions will be shipped in the course of another week.

The Manitowoc Boiler Company has at present a number of orders for sulphite digestors, some of which are now being assembled at their different stations. One, 14 feet diameter and 45 feet high, for the New York & Pennsylvania Company, of Johnsonburg, N. Y., is being erected at that place. This company is also building four 15-foot diameter by 49 feet high digestors for the International Falls Paper Company in Minnesota, two of which have been shipped and are being erected. The other two will be shipped in the course of a couple of weeks. They are also at present putting through their mammoth boiler shop four 16-foot diameter by 52 feet high digestors for the Marathon Paper Mills Company, of Wausau, Wis., one of these digestors being shipped this week and the balance before the end of the year. They are also building one 16-foot diameter and 46 feet high for export to Japan. They have also just completed three Scotch marine boilers 12 feet 6 inches diameter by 11 feet long for the new boat *Alabama*, which the Dry Dock Company is building for the Goodrich Transportation Company.

The Manitowoc Boiler Works also have at the present writing orders for six more digestors to be delivered in the spring. Between the digestor and the marine boiler work they will require a force of some 250 men this winter. The shops are at present running day and night in order to get out the orders which they now have on hand.



130-FOOT PIPE BUILT AT THE MANITOWOC BOILER WORKS AND SHIPPED IN ONE PIECE ON THREE CARS.

LAYOUT OF A TRANSITION PIECE.

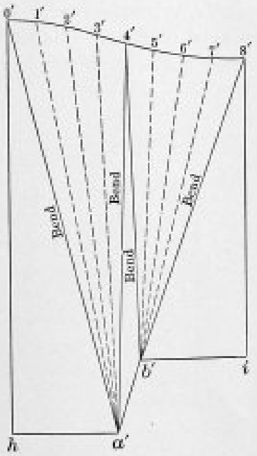
BY A. E. CLEMENTS.

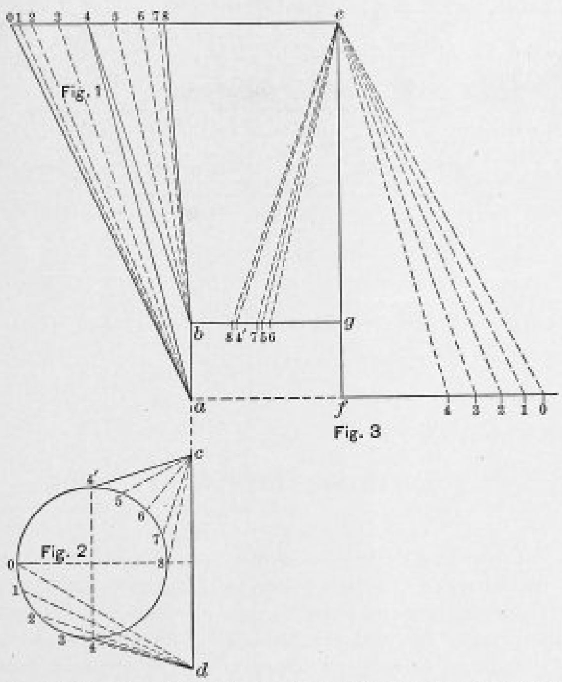
In the drawing here shown, Fig. 1 is a side elevation, and Fig. 2 a plan view of a connection between a rectangular base in a vertical plane and a round top in a horizontal plane. Such a connection can be laid out only by triangulation.

First, draw Fig. 1, the distance *a-b* representing the height of the rectangle. Then draw the plan, Fig. 2, the distance *c-d* representing the desired length of the rectangle. One-half of the plan is all that is necessary, but in this drawing opposite quarters of the circle have been used, so there would be no confusion of lines. Divide one-half of the circle, Fig. 2, into a number of equal spaces, in this case eight have been used, connect these points with *c* and *d*, also project them to Fig. 1, and by connecting these points with *a* and *b* the triangles are shown in that view. To the right of Fig. 1 draw Fig. 3, this being the diagram of triangles necessary to construct the pattern. First, draw a vertical line *e-f* in length equal to Fig. 1; at *f* and *g* draw lines at right angles to *e-f*, upon which set off the length of lines in Fig. 2 from *d* to *o*-1-2, etc., on the horizontal drawn from *f*, and from *g*, the distances *c* to 4', 5, 6, etc., connect the points thus located with *e*. These lines represent the true length of lines necessary to layout the pattern.

All measurements necessary are now obtainable from the two views and the diagram of triangles.

First, draw the right angle *a′ h o′*, making *a′ h* equal to one-half the distance *c* to *d*, Fig. 2, and *h o′* equal *a o* of Fig. 1. Draw a line connecting *a′ o′*; next, set a pair of dividers to the spacing of the circle Fig. 2. With this for a radius and *o′* as a center, strike an arc at 1′. Intersect this arc with one struck from *a′* as a center, and 1-*e*, of Fig. 3, as a radius, thus locating point 1′. Continue thus until point 4′ is reached, then with *a*-*b*, of Fig. 1, as a radius, and *a′* as a center, strike an arc at *b′*, which intersects an arc struck from 4′ as center,





and *e*-4′, of Fig. 3, as radius. From *b′* the remaining points 5′, 6′, etc., are located in the same manner that 1′, 2′, etc., were located. From 8′ as center, and with *b*-8, of Fig. 1, as radius, strike an arc at *i*, which intersects with an arc struck from *b′* as center, and one-half the distance *c*-*d*, of Fig. 2, as radius, draw lines connecting all points, and one-half the pattern is completed, the other half is a duplicate of this. All points in the pattern have been lettered to correspond with like points in the elevation.

Careful inspection of steam boilers when they are in the process of construction is quite as important as periodic inspection when they are in operation.

THE UTILIZATION OF FUEL IN LOCOMOTIVE PRACTICE.

"The Utilization of Fuel in Locomotive Practice" is the subject of a bulletin just issued by the United States Geological Survey. The author, Prof. W. F. M. Goss, of the technologic branch of the survey, makes the statement that locomotives in service on the railroads of this country consume more than one-fifth of the total coal production of the United States. "The amount is so large," says Prof. Goss, "that any small saving that can be made effective in locomotive practice at once becomes an important factor in conserving the fuel supply of the nation. For this reason the United States Geological Survey has given attention to the special problems of combustion in locomotive boilers."

In giving his conclusions as the result of the tests, Prof. Goss says: "There were in 1906, on the railroads of the United States, 51,000 locomotives. It is estimated that these locomotives consumed during the year not less than 90,000,000 tons of fuel at a cost of $170,500,000. That wastes occur in the use of fuel in locomotive practice is a matter well understood by all who have given serious attention to the subject, and the tests which have been made show some channels through which these wastes occur. These results are perhaps more favorable to economy than those attained by the average locomotive of the country, as the coal used in the tests was of superior quality, the type of locomotive employed was better than the average, and the standards observed in the maintenance of the locomotive were more exacting. But the effect on boiler performance arising from these differences is not great, and, so far as they apply, the results may be accepted as fairly representative of the general locomotive practice of the country. They apply, however, only when the locomotive is running under constant conditions of operation. They do not include the incidental expenditures of fuel which are involved in the starting of fires, in the switching of engines, and in the maintenance of steam pressure while the locomotive is standing, nor do they include a measure of the heat losses occasioned by the discharge of steam through the safety valve."

SUMMARY OF RESULTS OBTAINED FROM FUEL BURNED IN LOCOMOTIVES.

	Tons.
1. Consumed in starting fires, in moving the locomotive to its train, in backing trains into or out of sidings, in making good safety-valve and leakage losses, and in keeping the locomotive hot while standing (estimated).	18,000,000
2. Utilized, that is, represented by heat transmitted to water to be vaporized..........	41,040,000
3. Required to evaporate moisture contained by the coal	3,600,000
4. Lost through incomplete combustion of gases..	720,000
5. Lost through heat of gases discharged from stack	10,080,000
6. Lost through cinders and sparks..............	8,640,000
7. Lost through unconsumed fuel in the ash......	2,880,000
8. Lost through radiation, leakage of steam and water, etc..............................	5,040,000
	90,000,000

"The amount of fuel consumed in preparing locomotives for their trains, etc., is dependent only to a very slight extent on the characteristics of the locomotive, being in large measure controlled by operation conditions, by the length of divisions, and by the promptness with which trains are moved. Under ideal conditions of operation, much of the fuel thus used could be saved, and it is reasonable to expect that the normal process of evolution in railroad practice will tend gradually to bring about some reduction in the consumption thus accounted for.

"The fuel required to evaporate moisture in the fuel and that which is lost through incomplete combustion are already small, and are not likely to be materially reduced.

"The loss represented by the heat of gases discharged from the stack offers an attractive field to those who would improve the efficiency of the locomotive boiler. So long as the temperature of the discharged gases is as high as 800° F. or more, there is a possibility of utilizing some of the heat by the application of smoke-box superheaters, reheaters or feed-water heaters, though thus far the development of acceptable devices for the accomplishment of this end has made little progress.

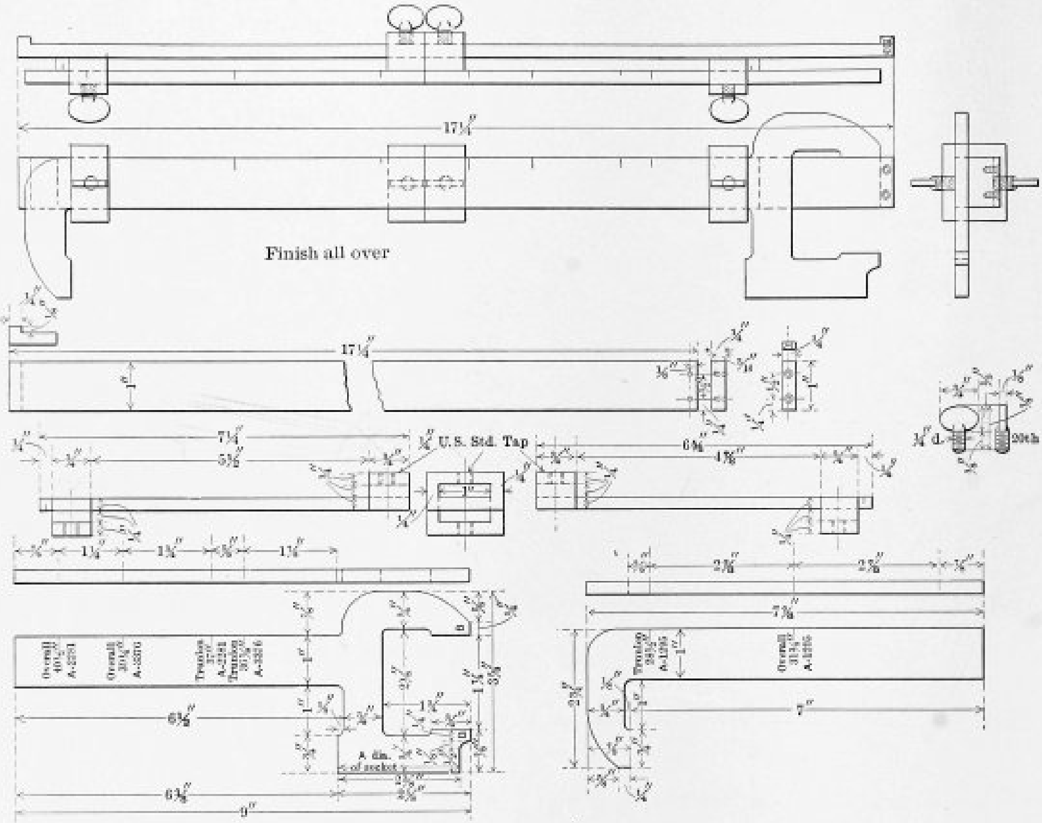
"The fuel loss in the form of cinders collecting in the front end and passing out of the stack is very large, and may readily be reduced. A sure road to improvement in this direction lies in the direction of increased grate area.

"Opportunities for incidental savings are to be found in improved flame ways, such as are to be procured by the application of brick arches or other devices. Such losses may also be reduced by greater care in the selection of fuel and in the preparation of the fuel for the service in which it is used. It is not unreasonable to expect that the entire loss covered by this item will in time be overcome.

"The fuel which is lost by dropping through grates and mingling with the ash is a factor that depends on the grate design, on the characteristics of the fuel, but chiefly on the degree of care exercised in managing the fire. More skillful firing would save much of the fuel thus accounted for.

"The radiation and leakage losses may in part be apparent rather than real, owing to possible inaccuracies in the process of developing the heat balance. On the assumption that the values are correct, as stated in this bulletin, however, it is not likely that under ordinary conditions of service they can be materially reduced.

"Locomotive boilers are handicapped by the requirement that the boiler itself and all of its appurtenances must come within rigidly defined limits of space, and by the fact that they are forced to work at very high rates of power. Notwithstanding this handicap, it is apparent that the zone of practical improvement which lies between the present-day results and those which may reasonably be regarded as obtainable, is not so wide as to make future progress rapid or easy. Material improvement is less likely to come in large measures as the result of revolutionary changes than as a series of relatively small savings in the several items to which attention has been called."



DETAILS OF AN INSPECTOR'S GRATE GAGE.

AN INSPECTOR'S GRATE GAGE.

BY C. E. LESTER.

In the past few years on the railroad with which I am connected there has been considerable trouble experienced with grates and grate frames, that is, consignments have been frequently received that would require machine work before they could be used in the engines. On different occasions it was found that the grates were sometimes too long over all, sometimes too long or too short on the trunnions; frequently the trunnions were too large for the socket in the bearing bars, and at times the sockets in the bearing bars were too small.

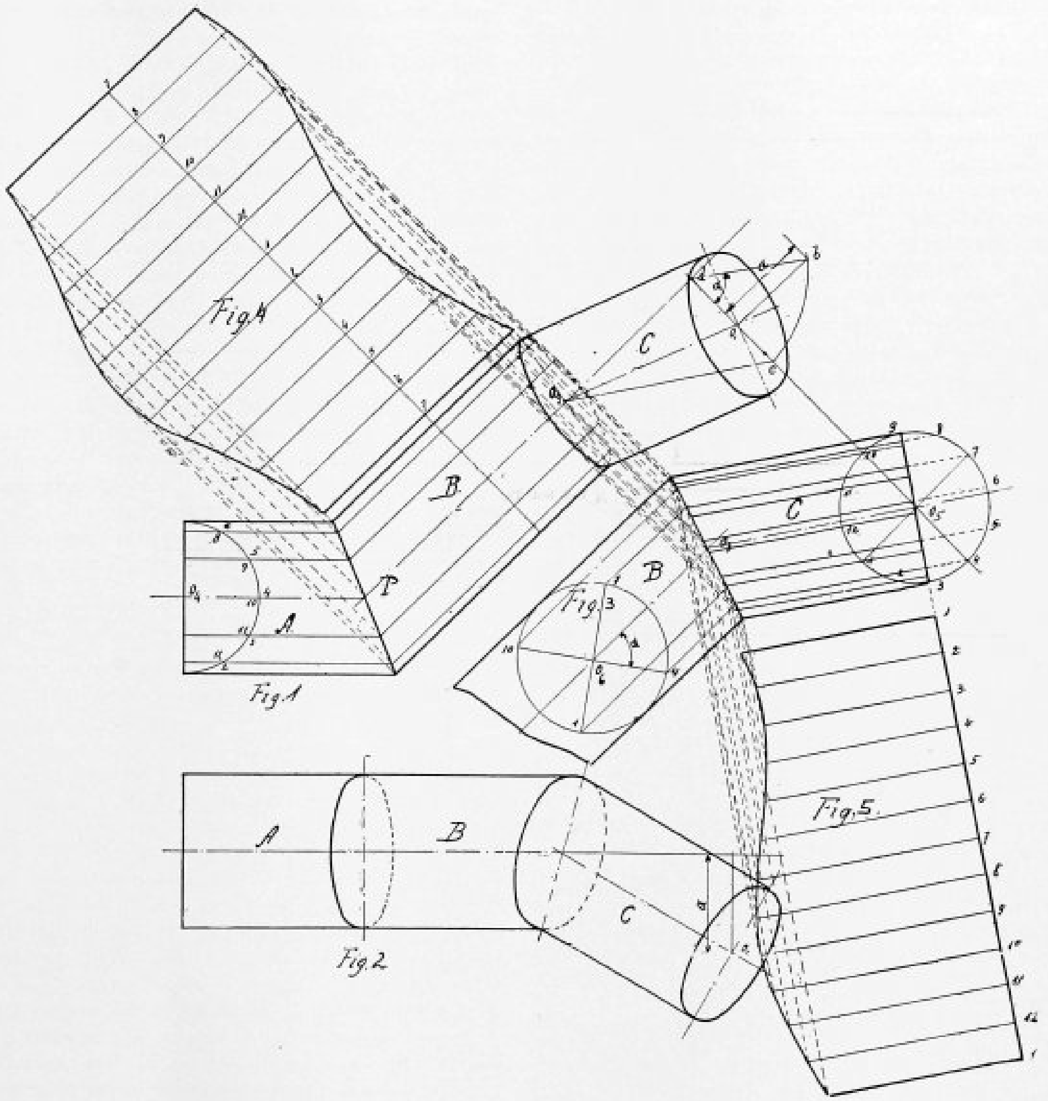
To overcome these defects it was very often necessary to machine the grates or bearing bars to make a fit. The several different prints for different classes of grates were checked over, the company's patterns at the different foundries were recalled and checked up, and an inspector was sent out to the several foundries who use their own patterns to cast grates for us, to check up their patterns. Notwithstanding all these precautions we still received grates that would not fit.

On account of the number of different classes of grates and bearing bars it would have taken a suit case for a traveling material inspector to carry all the drawings necessary to check up the dimensions on the different classes; hence the inspectors simply inspected the castings for surface defects and assumed that the several dimensions were correct. The accompanying sketches show an inspector's defect gage that the writer had designed to check, "over all," and trunion lengths on dead and shaker grates, the diameter of trunions on shaker grates and the size of sockets in the bearing bars of the different patterns shown on the drawings.

LAYOUT OF A DOUBLE ANGLE PIPE.

BY JOHN JASHKY.

The illustration shows three pipes intersecting at various angles. It is clearly evident that the pipes *A* and *B* are in the same perspective plan, while the pipe *C* brings in a new angle. The problem is to lay out the pipes *B* and *C*, since the layout of *A* is simple and can be understood from the drawing. Having Figs. 1 and 2, the part *P* of pipe *A* is easily laid



It will be noted by referring to the drawings that this gage will accurately check the dimensions necessary on three patterns of shaker grates, three patterns of dead grates, and four patterns of bearing bars. The section marked *A* checks the diameter of bearing bar sockets shown by the pattern number, and the section marked *B* checks the diameter of trunions of grates that have the pattern number shown. The "over all' and the trunion lengths are stamped on the face of the different sections with arrow points to designate the proper position of sections for different lengths. The gage could as well be made from two sliding sections as from the number it now has.

It was designed in this manner simply to be telescopic and allow the inspector to close it up so that it could be carried in a small hand bag along with other inspectors' tools.

out. The distances 7-8, 8-9, 9-10, etc., in Fig. 4, are the same as the arcs in Fig. 1.

For laying out the other part it is necessary to construct the auxiliary figure No. 3. This figure gives the upper part of the pipe and the whole pipe *C* laid in a new plan, so that the layout of the upper part of pipe *B* and pipe *C* can be easily found by well-known methods.

In finding this figure, draw in Fig. 1 a line through the center o_1, perpendicular to the line o_8-d, intersecting the line at *d*. Draw another line through the center o_1, perpendicular to the line o_1-d. Take the distance *a*, from Fig. 2, and make the distance o_1-b equal to *a*. Then draw the line *d*-*b* forming the angle α. Using *d* as a center, draw an arc, with *d b* as the radius, and intersect the line o_1d at the point *c*. Drawing the line o_1-c, the new center of pipe *C* is found. The center lines o_6-o_2 and o_3-o_6 in Fig. 3 are parallel to the lines o_3-d, and o_2-c in Fig 1. Then both pipes must be drawn with the intersection line a straight line. o_6 may be the center of a circle on the same circumference as the pipe. For finding the position of the points 1, 4, 7 and 10, and the others, draw a parallel line through o_6 to the line d-b in Fig. 1, forming the angle α. All other points are now easily found. The layout, Fig. 4, gives the layout of pipe *B*, and Fig. 5 that of pipe *C*.

THE OXHYDRIC PROCESS OF CUTTING AND WELDING METALS.

The new oxhydric process of cutting and welding had a rather dramatic introduction to the metal users of this country, in connection with a disaster at Milwaukee, Wis., where its usefulness was proved in the first public test to be made, anticipating by a week a series of demonstrations which were to have been conducted in the steel foundry of the Falk Company, Milwaukee.

THE BOILER EXPLOSION.

On the morning of Oct. 25 four boilers in the power house of the Pabst Brewing Company burst, causing the death of one man and the serious injury of a second, together with a property loss estimated at about $200,000. The explosion demolished the boiler house, threw one boiler section to the roof of an adjoining building, and moved a six-story steel frame grain elevator, which stood next to the boiler house, 4 feet sideways on its base.

The wrecked boiler house was 49½ feet wide and 161 feet long, and was only a few years old. It was of brick construction. The building contained eight boilers arranged along the south side of the building. They were divided into two sections of four each, with a brick stack between them. Two Edge Moor boilers had only recently been set in place, and were not yet in service. The other six were Munoz boilers. As near as can be determined four of these boilers at the east end of the boiler house exploded. Whether they all exploded at the same instant or whether the wrecking of one so weakened the others that they also burst is hard to determine. However, the latter is probably the case, as it seems the men had some sort of warning before the wreckage was complete, and some succeeded in getting out doors.

The boilers were of the watertube type. The main bank of tubes was fastened to the usual serpentine header, which in turn connected to a cast steel yoke or header between the two steam drums. These drums were 36 inches in diameter, and the steel was ⅜ inch thick. At each side of the furnace was a row of vertical tubes running from a mud drum to the steam drums. Where these tubes entered the drum the latter was reinforced by a sheet of steel extending the entire length of the drum. This sheet was fastened by a single row of rivets at each side. The rivet holes had a pitch of 2⅞ inches, and were 13/16 inch diameter. An examination of the exploded boilers seems to indicate that they all failed in the same place, which was lengthwise of the drums, through the rivet holes on each side of the plates mentioned. In most cases this plate was found still fastened to the vertical tubes and mud drums. The remainder of the steam drums and the banks of tubes were a tangled mass of wreckage, spread, for the most part, about the wreckage of the boiler room.

At 11 on the morning after the explosion, a hurry call was received at the plant of the Falk Company, asking that the oxhydric apparatus, being developed by this company, and operators, be sent to the Pabst plant to assist in clearing away the wreckage of tangled metal. Only four men in this country have yet had experience in handling the oxhydric process. These are Primo Lulli, of Genoa, who invented the process; Hans Mueller, a Belgian, who perfected the apparatus, and two Americans connected with the Falk Company, who have mastered its use. Ten minutes after the call came these four men were rushed in an automobile with their apparatus to the Pabst works. There, under the personal superintendence of Herman Falk, they began cutting through steel girders, metal sheets and great banks of iron to clear the plant in the shortest possible time. For nearly twenty-five hours these men continued their work, until Lulli was injured by a falling beam. After a short rest during the day the other three men continued to work through the night. Hans Mueller had his foot crushed by a sliding mass of metal and was compelled to drop out. The two remaining operators, Americans, continued to clear away the wreckage until it was possible to clean everything out and start the repair work.

One of the most unique pieces of work done at the Pabst plant was in the cutting of a large, square hole in the bottom of an overturned coal bunker. In falling, this bunker with the coal it contained had turned turtle, and lay bottom side up, so it was impossible to get at the coal. No machinery at hand was capable of lifting the bunker, so the expedient of cutting through the upturned bottom was resorted to. In a few minutes a hole 3 feet square was cut, and made possible the removal of the coal.

OTHER TESTS OF THE APPARATUS.

Before this application of the oxhydric apparatus to commercial work it had been thoroughly tried out in shop tests. One of the most striking of these was the cutting of a piece of 9-inch chrome-nickel steel to a circular outline. This was done at a speed of a linear foot of cut in two and one-quarter minutes. The apparatus has also proved useful in cutting thinner pieces, or patterns requiring an irregular outline, as will be mentioned later.

THE APPARATUS.

The apparatus used in obtaining such remarkable results is an adaptation and improvement of one patented in 1901 by the Cologne Meusen Mining Company for opening plugged blast furnace tap holes, and which is quite extensively used in this country. This original device has cut holes through more than 4 feet of solid metal in about 4 percent of the time formerly required. Both the original and the new apparatus use two nozzles, one of which supplies a mixture of oxygen and hydrogen, while the other furnishes pure oxygen. The effect of the original device is to melt the metal, and for such purposes is entirely satisfactory, but it cannot produce a smooth, accurate cut of any length. With the improved apparatus one nozzle, delivering mixed oxygen and hydrogen, is used for preheating the metal to the required temperature. A second nozzle, fastened to the first in such a way that it always follows the first, and set so that the streams of gas from both nozzles strike the metal in the same place, delivers only pure oxygen.

The oxhydric process is based on the chemical attraction which exists between iron and oxygen, whereby iron in an atmosphere of oxygen burns freely and rapidly. The action is particularly pronounced if the iron has been heated before coming in contact with the oxygen. With the apparatus described the preheater raises the iron to a temperature of from 1,300 to 1,500 degrees F., which is the temperature at which the oxygen acts most freely on the iron and produces different forms of oxides. The whole action is to cut the metal by oxidizing it without melting it, and the oxides formed are blown away by the force of the blast. The resulting cut is similar to that which might be made by a cutting tool. The effect of the heating is only local, and does not penetrate more than 1/64 inch into the surface of the cut, the width of which is no greater than a saw cut.

The new double-nozzle torch can be used on thick or thin plates, twisted sheets, structural shapes, castings, tubes, and, in short, on any piece where the flame can be applied. It may be controlled by hand or in a mechanical device especially designed for the work. Lines of any sort can be followed, the circular or irregular curve being worked as successfully as the straight line. Beveled or perpendicular cuts can be made with equal ease, and the width of the cut is practically uniform from top to bottom. Harveyized high manganese or nickel-chrome steel, tempered, or hardened, forged, cast, or rolled steels can all be cut.

The complete apparatus for cutting consists of two steel bottles, which contain the oxygen and hydrogen, the pressure gages which go with them, the mixing chamber, the nozzles, and the armored tubing carrying the gas. The pressure maintained in the bottles varies from 1,500 to 2,000 pounds per square inch. The gas leaves the bottle through a needle valve, which admits it to a pressure-regulating valve that constantly maintains an even flow and pressure from the bottles through the mixer to the nozzles. A low-pressure gage on the regulating valve serves to guide in the setting of the valve for various kinds of work, while a high-pressure gage on the bottle can be used in determining the amount of gas used. Heavily armored rubber tubes convey the gas to the mixing chamber, which is separate from the rest of the apparatus and water-cooled to safeguard against explosion. Worm-shaped conical pipes in the mixer combine the two gases thoroughly before they leave. More heavily armored rubber tubing conveys the gas to the nozzles already mentioned.

TABLE I.

Number of Piece.	Thickness of metal in inches.	Consumption of gas for each lineal foot of metal cut. Oxygen.	Hydrogen.
1	1⅛	3.9	3.9
2	2	4.8	4.8
3	2⅞	8.3	6.8
4	4	14.4	7.7
5	4⅛	15.5	8.8
6	4½	17.5	9.0
7	6½	22.3	10.3

TABLE II.

Thickness of metal, inches.	Size of nozzle for cutting or oxygen torch, inches.	Size of nozzle for heating or oxhydric torch, inches.	Cubic feet of gas used for each lineal foot of metal cut. Oxygen.	Hydrogen.
0.2	0.06	0.12	1.5	1.5
0.4	0.06	0.12	1.9	1.9
0.6	0.06	0.12	2.2	2.2
0.8	0.06	0.12	2.5	2.5
1.0	0.08	0.16	2.9	2.8
1.2	0.08	0.16	3.3	3.2
1.4	0.08	0.16	3.8	3.4
1.6	0.08	0.16	4.4	3.6
1.8	0.08	0.16	5.1	3.8
2.0	0.08	0.16	5.8	3.9
2.2	0.08	0.16	6.5	4.1
2.4	0.08	0.16	7.2	4.3
2.6	0.08	0.16	8.0	4.6
2.8	0.08	0.16	8.8	4.8
3.0	0.08	0.16	9.7	5.0
3.2	0.08	0.16	10.7	5.3
3.4	0.08	0.16	11.8	5.6
3.6	0.08	0.16	12.8	6.0
3.8	0.08	0.16	13.9	6.4
4.0	0.08	0.16	15.0	6.9
4.2	0.08	0.16	16.2	7.4
4.4	0.08	0.16	17.5	8.0
4.6	0.08	0.16	18.8	8.5
4.8	0.08	0.16	20.2	9.0
5.0	0.08	0.16	22.7	9.5

Table II.—Amount of gas and size of torch used while cutting steel from 1/10 to 5 inches thick.

GAS CONSUMPTION.

This apparatus has been in use abroad long enough now so that quite accurate figures are obtainable as to the amount of gas, size of nozzle, etc., necessary. Table I. gives figures of the cubic feet of gas used in cutting slabs of various thickness of metal from 1⅛ to 6½ inches. On 4-inch metal the cut was ⅛ inch wide, while on thinner metal it was only 5/64 inch. The surfaces are as smooth as a saw would leave them. Table II. gives a somewhat closer graduation of gas consumed.

ADAPTATION.

Different appliances have been designed for cutting various shapes. One is arranged so that the torch can be moved in two directions at right angles to each other. With this device strips of steel ⅛ inch wide have been cut. Other appliances are furnished for cutting circular and irregular shapes. These are all so arranged that the preheating nozzle precedes the oxygen nozzle. In the cutting of steel tubes this method has proved extremely successful. A special attachment is made, which holds the tube firmly in the center and provides means for rotating the torch outside. This can be used on either plain or flanged tubes. Table III. gives the gas consumption for cutting different diameters of pipe. The oxhydric flame can be used also in cutting manholes and irregular openings wherever needed, and much quicker than by other methods. Rivets are easily taken off, and the apparatus proves itself useful in many ways in the machine and boiler shop. In the cutting up of junk to sizes suitable for charging it has proved very effective. In one case an old armored cruiser was dismantled and cut into scrap in two and one-half months, where similar jobs before had taken a year and a half. In the foundry it is useful in removing sprues, risers, etc., which it cuts off cleanly and regularly.

OXHYDRIC WELDING.

It has been found that the oxhydric process is applicable to the art of welding as well as in the cutting of metals. However, for welding a single nozzle is used, which burns only the mixed hydrogen and oxygen gases. This flame reduces rather than induces oxidation, which latter is undesirable in welding. Except for the single nozzle and the single hose from the mixer, the apparatus used is the same as that described previously.

This method of welding does not affect the ductility of the metal. A light hammering of the joint, while the metal is cooling, or applying a heat treatment after the metal is cooled, will generally make the joint nearly as strong as the original metal. In the older fusion method of welding thick plates they are quite commonly made with the joints in the form of a V. This is then filled by melting metal from a rod. If the metal is properly fused a good joint results, but if drops of hot metal are allowed to fall on a joint not properly heated, the two will not fuse and the joint will be imperfect.

With the oxhydric process applied to sheets from ⅛ to 1 inch thick, the two pieces to be welded are placed with their ends in contact, but not lapping. Two oxhydric torches are used, one on each side of the metal, and exactly opposite. The flame contact is made as broad as possible. By the time the surface metal begins to show signs of melting it is probable that the interior of the pieces are at a white welding heat. At this point the torches are removed and the joint lightly ham-

TABLE III.

Thickness of metal.	Outside diameter of tubes in inches.																		
3/32 to ⅛	2	2⅜	2¾	3¼	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
⅛ to 3/16	..	..	..	..	3¾	4¼	4¾	5¼	5¾	6¼	6¾	..	..	..	..	..	..	..	..
3/16 to 5/16	..	..	..	..	..	..	..	..	..	..	..	7¼	7¾	8¼	8¾	9½	10	10¾	12
	Cubic feet of gas consumed.																		
Oxygen	2.3	2.6	3.2	4.5	5.2	5.9	6.6	7.4	8.1	8.8	9.5	14.4	15.3	16.3	17.3	18.0	19.0	21.5	24.0
Hydrogen	7.4	8.7	10.4	13.0	18.0	20.5	23.0	25.5	28.0	30.5	33.0	50.0	53.5	57.0	60.5	66.0	70.0	75.0	83.0

Table III.—Amount of gas used for cutting and welding tubes from 2 to 12 inches in diameter.

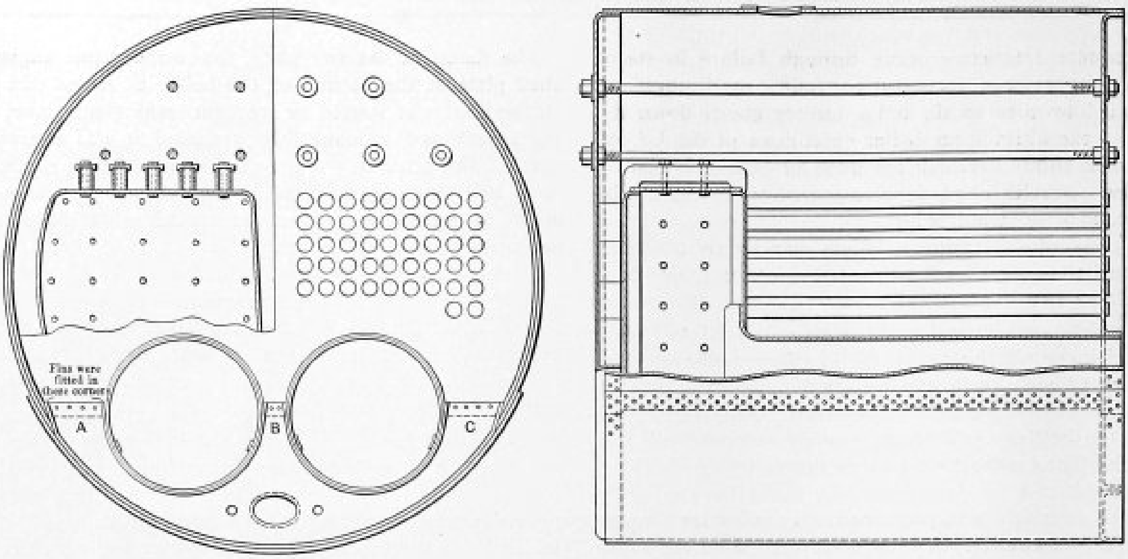


FIG. 1.—PARTIAL SECTION OF CORRODED BOILER, SHOWING PORTION OF HEAD AND SHELL REMOVED.

mered on an anvil, which completes the weld by a rearrangement of the molecular structure.

When this process of welding was first conceived there was a difficulty which was hard to get around. The welding gas should consist of one part of oxygen to four or six parts of hydrogen, and it is important that all the oxygen be absorbed in order to produce a flame of uniform character. A gas with these proportions is very explosive, and at first there was fear from this source. The difficulty was surmounted by causing the gas to travel at a speed greater than that of flame propagation. The velocity of flame propagation depends on the kind of gas and increases as the square of the tube section. This being the case, an explosive gas will not ignite in its containing tube if given a velocity greater than that of flame propagation, and this was done in the present case. Having thus determined the minimum velocity, the maximum velocity was determined from the practical consideration that the jet of gas must not be strong enough to disturb the drops of molten metal which constitute the weld. The torch used in the welding process has an enlarged chamber, which the gas first enters, which materially reduces its velocity. From this it passes through a conical tube having a smooth interior, and which has a bore gradually decreasing in size until the nozzle is reached. The dimensions of this tube and nozzle are so proportioned that the gases attain the desired minimum velocity on leaving.

FIG. 2.—RESULT OF CORROSION AND PITTING IN THE LOWER PART OF THE BOILER SHELL.

The American Oxhydric Company, Milwaukee, Wis., has developed the methods described, and manufactures the various devices necessary for its use. It also manufactures commercially the oxygen and hydrogen, and supplies it in the metal bottles mentioned. The cost of this method of cutting and welding is claimed to be no greater than by other methods. No machinery is necessary, and the portability of the apparatus makes its use extremely flexible.—*The Iron Age.*

What Corrosion Did to a Boiler, and How the Boiler Was Repaired.

BY EVAPORATE.

In a certain sense, it can be said there is no more important part in the mechanism of a steaming craft; no more vital part than the ordinary work-a-day, unoffending steam boiler. We frequently have heard it stated by the sea-going engineer, for instance, that at no time while "making the voyage" with everything well "under weigh," does any part of the engines, however intricate, under his charge, give him unusual thought or concern, to the same extent as does that part of the equipment where the power is being generated.

And the reason for this attitude is not far to seek. Particularly is this the case where the boiler or boilers have reached a fair age, or where some part of wasted plate or landing edge or other defect is known to exist. So much of the "hidden" element is present in the boiler; so much that can be hid away in the "secret recess" of the boiler, which is positively dangerous, in certain circumstances, that on a moment or two's reflection it is evident that the engineer's dread is not altogether baseless.

That disasters frequently occur through failure in steam boilers, which previous examination failed to discover or anticipate, is known to us all, and a cursory glance down the summary of casualties from boiler explosions in the United States (which forms anything but pleasant reading) reveals the amazing possibilities of dangers stored up in the much-abused, unobtrusive steam boiler.

But you may say, this involves a question purely of boiler management, whereas we are interested rather in boiler construction. Precisely! but it might not be lamentably out of place here were we to discuss or describe or merely refer to a boiler which came under our notice recently, in which serious consequences might have resulted through internal corrosion but for the vigilance of the boiler inspector. And be it noted here, it is our opinion that the comparative immunity from serious accidents accruing from faulty boilers is not so much or exclusively the result of careful management as from the now compulsory order by the various boards or authorities, which makes it imperative that a periodical examination and test be made by competent persons.

The boiler to which we wish to refer was of the ordinary Scotch marine type, and everything goes to show that the construction of the boiler was quite up to the requirements of the Board of Trade or insurance committee. Its design is readily seen by referring to Fig. 1, and its construction calls for no passing comments, except to draw attention to the method of flanging of the front-end plate, which, perhaps, although not universally popular, has some obvious advantages in the driving of shell rivets, for instance, over the internal flange, which is the more popular method of the two.

Owing to an extraordinary amount of wasting of the plates on the interior of the boiler, caused by the chemical action on the materials of the boiler by acids introduced with the feed water, it was deemed necessary to cut out and renew the part shell plate at the bottom of the boiler from the center line of the bottom of one furnace to the center line of the bottom of the other.

The flange at the end plate, too, where same engaged the shell plate at the bottom of the boiler at either side of the sludge door was wasted by frequent leaking to a most alarming extent, and to make this part good it was essential that part of the head be cut out, as shown in Fig. 3, and as is seen, still another piece had to be cut out, this time at the mouth of one of the furnaces extending inwards about 9 inches and about 2 feet circumferentially.

On consideration of the comparatively low cost of this type of boiler, a repair of such magnitude, which the wasted condition of the plates demanded, suggests at the outset an unprofitable undertaking. On estimating the cost of the repair, however, the condition of the other parts of the boiler, which were practically as good as new—for nothing could be more erratic in its effects on boiler plates than internal corrosion—weighed considerably in the minds of the vessel's owners in coming to a decision, *i. e.*, the cost of the repair, since the whole thing was tabulated out at something like 25 percent of the cost of a new boiler.

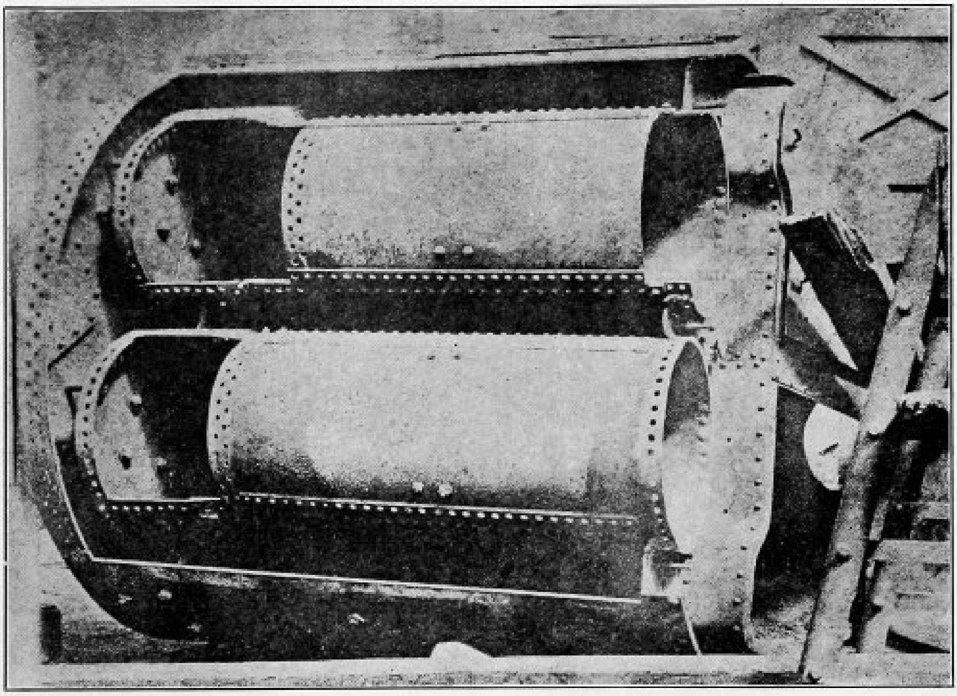


FIG. 2.—CORRODED BOILER WITH BOTTOM OF SHELL REMOVED, SHOWING PATCHES FITTED TO COMBUSTION CHAMBER.

When the part of the shell plate had been cut out and removed, it was discovered that the bottoms of the combustion chambers had suffered by the pitting, to the same extent as in the case of the parts already referred to, and as Fig. 3 shows, the wasted parts had to be cut out and patches fitted.

The work on this boiler was most expeditiously done, the time required from start to finish being barely three weeks. In cutting away the bad part of the shell plate pneumatic tools were used, and, as already hinted, the cutting extended the entire length of the boiler, and at each end of the plate remaining (after cutting) a tail end was left about 2 inches long at line of the circumferential rivet holes, to allow of a two-holed scarf being made where the new plate would overlap and form three-ply corners.

The rivets in front and back-end plates were drilled out at the places indicated and in the lower half of one furnace mouth. The other half required to be cut some 9 inches beyond the rivets, to take out the wasted landing edge.

The two large stays, placed fore and aft near the sludge

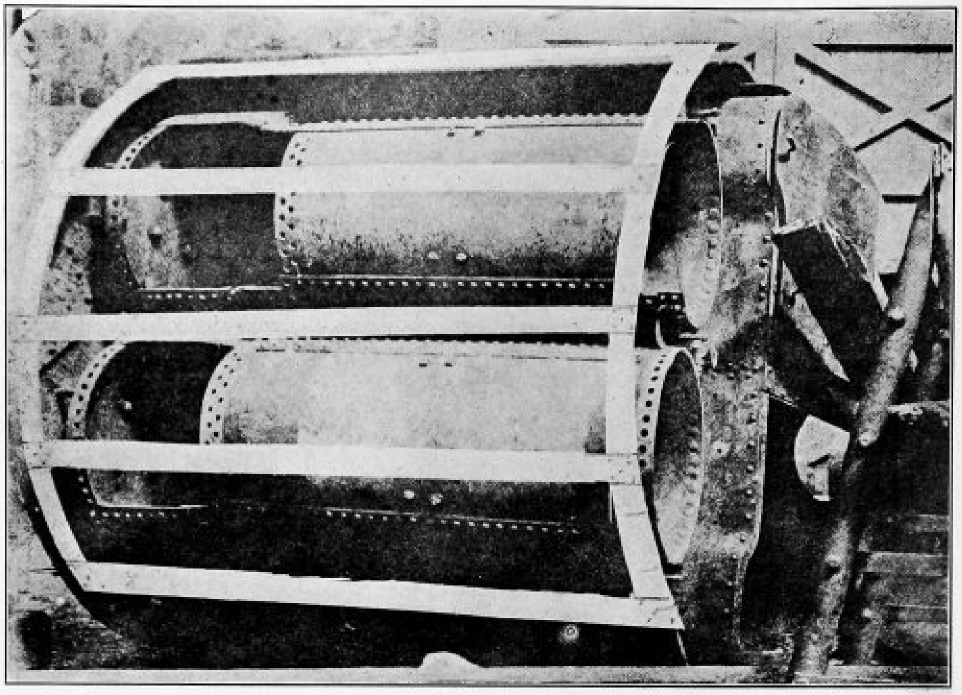


FIG. 4.—TEMPLATE FOR BOTTOM OF SHELL PLATE.

door, were then drilled out at the back end and were allowed to remain in the front end, to be removed along with part of the front plate, which was cut at *A*, *B* and *C*.

With all the cutting out completed, and the rivets cleared from the holes, the part as shown was lifted off and access obtained to the bottom of the chambers, where the parts were cut out as shown.

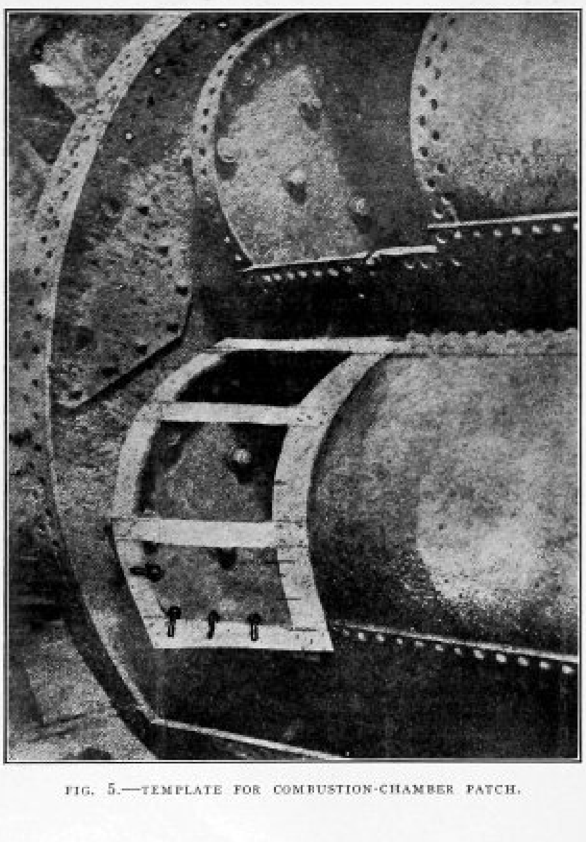


FIG. 5.—TEMPLATE FOR COMBUSTION-CHAMBER PATCH.

The various plates where cut were now lined in for rivet holes as required in the case of the shell plate; triple riveting was adopted. The holes were soon drilled with an air drill, that most useful adjunct to repair work.

A new plate had meantime been flanged on the sectional flanging-press and fitted carefully to its place at the boiler front, particular care being expended on the fitting of the joints *A*, *B* and *C*, where riveting was necessarily single, and where it would not be possible to drive rivets at the extreme corners. These corner holes were eventually tapped and pins fitted into them and riveted over.

The rivet holes were now marked in position, double riveting where it was to meet the shell plate and single in other places. The holes for the end-to-end stays were then marked in, and after they had been drilled they were tapped. With all rivet holes drilled in it, the end plate was replaced in the boiler to permit the shell plate being made and fitted. Before the shell plate had been proceeded with, templates were made of patches for the bottoms of the combustion chambers by means of lath wood about ⅛ inch thick and of the requisite breadth.

Pieces of sheet-iron packing were inserted between the pattern and plate till the outer edge of the template was at a distance from the furnace, equal to or equivalent to, one-half the thickness of plate proposed to be used.

A good rule for this style of template, to put it briefly, is to reckon the thickness of template, plus packing, equals half the thickness of plate, plus 1/64 inch.

The templates were then marked in their respective place and all holes lifted by means of "reversers."

The plates were soon ready to be placed on the chamber bottoms, set to gage, and annealed when they were thoroughly bolted up, riveted, and calked inside and out.

The two new stays were next placed in position, thus insuring that the new part front plate would be kept in position during the marking of the shell plate.

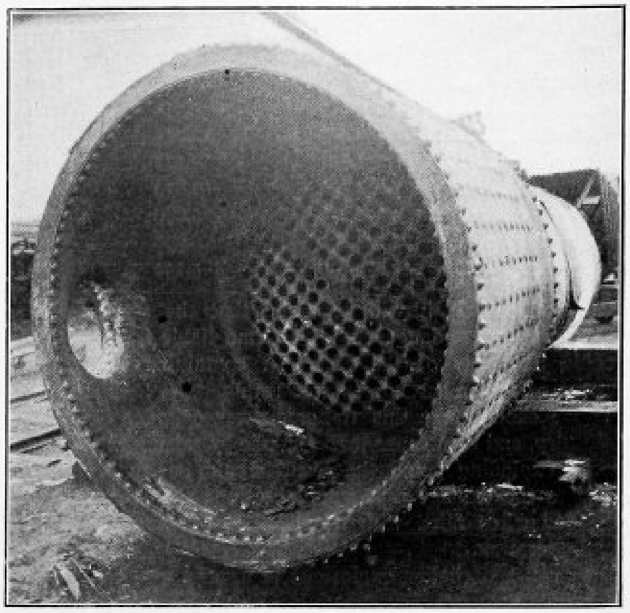
The pattern for the shell plate was made in a similar manner to that employed for the patches on the chamber bottoms by the afore-mentioned rule. The plate was marked, drilled and rolled to set and bolted up. Riveting and calking soon followed.

A patch was meantime fitted at the furnace mouth where cut, but as same was so small no template was required for it.

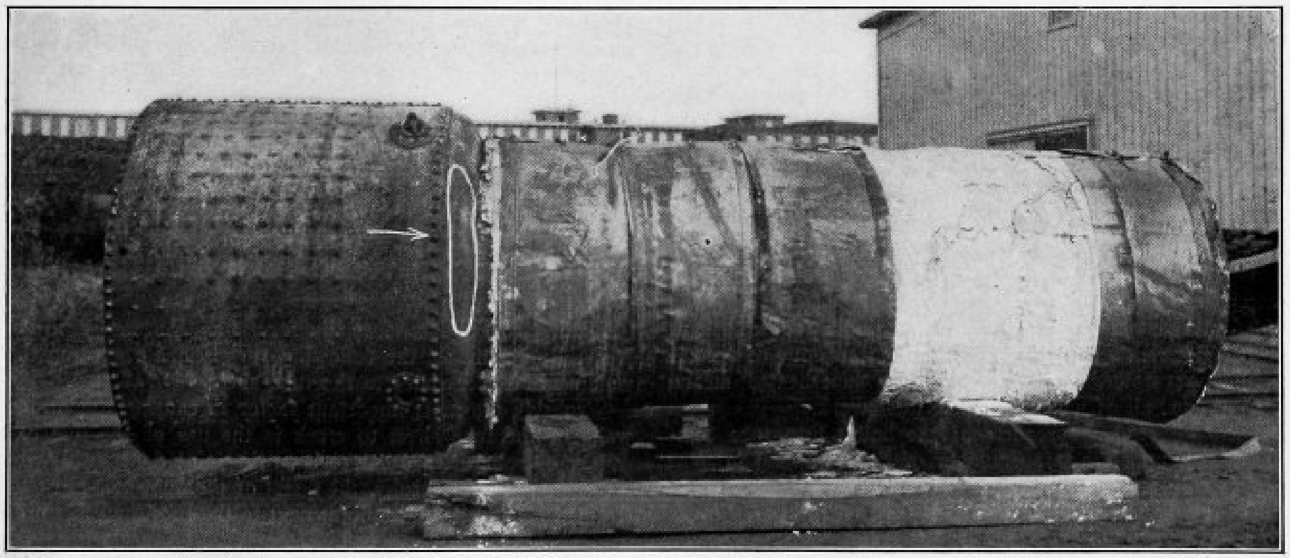
First Explosion of a Manning Boiler.

The photographs show a standard 150-horsepower Manning boiler having a 6-foot furnace and 182 tubes 2½ inches diameter by 15 feet long. The boiler was fitted with a Jones underfeed stoker, and was being heavily forced, forming one of a battery of twelve supplying a Mackintosh & Seymour engine, which was direct connected to a 2,500-kilowatt General Electric generator, and which was at the time of the explosion developing about 4,500 horsepower, or about 375 horsepower per boiler. The tube ends slipped out of the lower tube sheet, and the boiler shot up like a skyrocket. No other boiler was disturbed, and after the explosion all of the other boilers stood a hydrostatic test of 300 pounds per square inch gage.

The cause of the explosion is assigned to the fact that the water probably lifted long enough to cause the tube ends to draw out of the lower tube sheet.



INTERIOR OF FIRE-BOX, SHOWING BAGGED TUBE SHEET.



MANNING BOILER AFTER EXPLOSION, SHOWING AMOUNT OF EXTERNAL DAMAGE.

STEAM BOILER EXPLOSIONS.*

BY FREDERICK L. RAY.

Just what happens when a steam boiler explodes is best told in the words of Prof. Airy, in a paper read before the British Association in 1863, and quoted by Dr. Thurston in his *Manual of the Steam Boiler,* as follows:

"Very little of the destructive effect of an explosion is due to the steam which is confined in the steam chamber at the moment of explosion. The rupture of the boiler is due to the expansive power common at the moment to the steam and water, both at a temperature higher than the boiling point; but as soon as the steam escapes, and thereby diminishes the compression force upon the water, a new issue of steam takes place from the water, reducing the temperature. When this escapes and further diminishes the compression force, another issue of steam at a lower elastic force from the water takes place, again reducing the temperature; and so on, until at length the temperature of the water is reduced to the atmospheric boiling point, and the pressure of the steam (or rather the excess of steam pressure over atmospheric pressure) is reduced to 0."

From this statement we are to believe that the amount of steam in a boiler at the time of explosion is of little consequence compared with the effect produced by the sudden liberation of a large body of water under a high pressure of steam.

The energy stored in a steam boiler is capable of computation, and when computed shows conclusively that an exploding boiler can easily do all that ever has been charged against it. The following table gives the total stored energy in steam boilers of different types, also the maximum height of projection, in feet, should all the stored energy be directed in projecting the boiler upwards:

* Abstract of paper read before Kentucky No. 1, N. A. S. E., of Louisville, Sept. 29, 1909.

Type.	Foot Pounds Energy.	Max. Height Projected.	H. P.
Plain cylinder.....	47,281,898	18,913	10
Cornish	58,260,060	3,431	60
Two-flue	82,949,407	12,242	35
Plain tubular......	51,031,521	5,372	60
Locomotive	71,284,592	2,872	650
Flue and return...	104,272,276	2,689	300
Scotch marine.....	72,734,800	996	180
Watertube	200,879,830	5,130	250

From the table it will be noted that the plain cylinder boiler is the most dangerous of all, and liable to cause more trouble than any of the others, it containing the greatest amount of water per horsepower rating.

If we should take this 10-horsepower cylinder boiler and boil it dry, and then cause it to explode by raising the pressure to the exploding point, the result would be small, as compared to the damage that would be done if the same boiler exploded when filled with water up to the point carried in usual operation.

The cause of boiler explosions is usually well understood, and when the cause cannot be found it is because the evidence has been destroyed by the accident.

The "mysterious" boiler explosion is a thing of the past. The actual cause of a great majority of explosions is determined by skilled engineers, who are able by examination of the exploded boiler, or parts of same, to say with certainty just what caused the particular explosion.

Over-pressure of steam, or weakness of the boiler, are the usual causes of explosions. Over-pressure of steam may be caused by closing steam outlet when boiler is performing maximum duty, or pumping water onto over-heated plates or by failure of safety valve.

Weakness of boiler may be caused by deterioration of metal, due to age, or to poor management, or poor design, causing unequal strains in joints or stays; added to these are defective material and faulty workmanship.

Many reasons have been advanced to account for explosions, such as electricity, explosive mixture of gases, due to decomposition of water, retarded ebullition, superheated steam, flooding, etc., all of which are mere guesswork.

When we read the reports of the boiler insurance companies, and note the large number of boilers found in dangerous condition, we naturally wonder why there are not more explosions than actually occur.

Don't buy a boiler because it is cheap, for it is apt to be dear at any price.

There are boiler makers who will use cheap materials and unskilled workmen who will cover defects with a coat of paint, thereby jeopardizing life and property.

Knowing as we do the great energy confined in the steam boiler, we must appreciate the importance of rigid specifications and strict compliance therewith in both manufacture and installation. Too much stress cannot be laid upon the necessity of having the boiler insured in a reliable company whose specialty is a proper and thorough inspection of boilers at stated intervals, and oftener should occasion require.

In conclusion, I will quote from Thurston's *Manual on Steam Boilers:*

"The prevention of steam boiler explosions is now seen to be a matter of utmost simplicity. A well-designed, well-made and set and properly managed steam boiler may be considered as safe. Explosions never occur in such cases. To secure correct design and proportion, a competent engineer should be found to make the plans. To obtain good construction, a reliable, intelligent and experienced maker must be intrusted with the designs; and the latter should attend to the installation of the boiler.

"In order to secure good management, trustworthy, skillful and experienced attendants must be found, who, under definite instructions, may at all times be depended upon to do their work properly. Periodical inspection, prompt repairs of all defects when discovered, and the removal of the boiler before it has become generally deteriorated and unreliable, are absolute safeguards against explosions."

The following statistics will be of interest, because we are all personally interested, realizing that some one of us may be the next victim added to the list: Two hundred and fifty are killed and 400 injured each year by boiler explosions.

In forty-one years there have been 10,000 explosions, resulting in the killing of 10,884 people, and injuring 15,518, as reported by the Hartford Steam Boiler Inspection & Insurance Company.

The most disastrous explosion in history was that of the steamer *Sultana* on the Mississippi River in 1865, when 1,238 persons were killed. The steamer was bringing soldiers home at the close of the war. The boiler pressure allowed was 70 pounds, but at the time of the accident 150 pounds was being carried; the boiler was of the return-tubular type, in poor condition and much overworked.

The worst explosion in recent years occurred in Brockton, Mass., in which fifty-eight were killed and 117 injured. The explosion was due to the shell breaking at the lap joint. The boiler was insured and regularly inspected and had good care, and yet it exploded from a cause beyond the ability of man to guard against. The remedy for such a case is to do away with the lap joint, and in its place have nothing but the butt-strap joint.

In the United States we have but four States which have engineers' license laws, and only thirty-five cities outside those States that have municipal regulations governing the examination and licensing of stationary engineers.

WELDING BOILER TUBES TO THE TUBE SHEET.

Writing to the *American Engineer and Railroad Journal,* J. W. Rupert makes the following suggestions regarding the welding of boiler tubes to the tube sheet:

"Probably the most important factor in causing the bridge walls of the tube sheet to crack is the use of the flue expander or roller. In order to keep the joint tight, even with the use of copper ferrules, the metal of the flue sheet must be strained beyond its elastic limit next to the tube, and this process repeated many times causes incipient cracks, which, under the stresses due to the heat of the furnace, ultimately results in the entire disruption of the metal between the tubes. The use of the expanding tools is rendered necessary because of leakage of the flues, and therefore if we are able to secure and maintain tight joints without the use of the expander, and without straining the metal at this point, it would seem that the life of the sheet would be increased, and the troubles due to leaking tubes obviated.

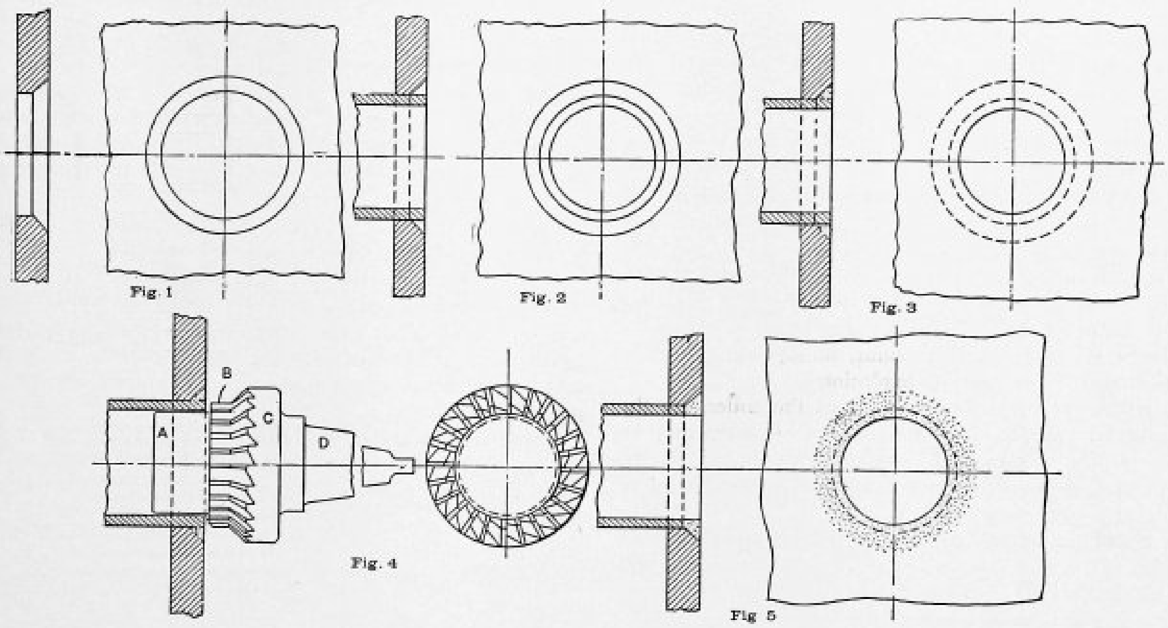
Since the oxy-acetylene process of welding has entered the railroad field, I have looked in vain for a description of the method of using this process to weld the tubes to the tube sheet. While radical, this seems to me to be entirely feasible, and I understand is being used at least experimentally at some points. In studying the subject I have evolved the following method of welding the tubes, and propose a means of removing them, when necessary on account of scale, which would leave the hole the exact size for the insertion of the new tube, and also prepared for the welding-in process, all in one operation.

"Referring to the sketches, Fig. 1 shows the tube sheet with the hole drilled and the fire side counterbored at the desired angle (say 45 degrees) for about one-half the thickness of the plate, to allow clearance for the welding process. Fig. 2 shows the tube inserted, with the end flush with the fire side of the sheet. Fig. 3 represents the tube welded into the sheet, the dotted portion being the filled-in part of the weld. If properly done this should give a homogeneous structure throughout the welded portion, the surface of the tube and of the sheet being fused. This should prohibit all leakage at this point. It will be noted that there are no projections to be burned off by the furnace fire.

"In order to remove the tubes for cleaning, the tool shown in Fig. 4 is suggested. This is intended to be driven by either an electric or pneumatic motor, through the shank '*D*.' Part '*A*' is a guide, slightly less in diameter than the internal diameter of the tube; '*B*' is an end reamer, the outside diameter of which is the same as the outside diameter of the tube, the difference in the diameters of '*A*' and '*B*' representing twice the thickness of the tube wall. The length of part '*B*' can be more than one-half the thickness of the tube sheet. Part '*C*' is a reamer having a bevel that gives the desired counterbore to the tube sheet. A shank '*D*' provides means of driving the reamer. This tool can be made out of one piece if desired, or the sheet may be counterbored later by a separate tool.

"Should difficulty be experienced in getting a good weld on the under side of the tube, as shown in Fig. 2, the method indicated in Fig. 5 may be used, where the tube is inserted only one-half way through the sheet, and metal added to complete the weld, as indicated by the dotted portion. The same tool would be used to cut out this tube as though the previous method were used.

"The writer would be glad to hear criticisms of the above method, or to learn of any case where the tubes have been welded in."



ILLUSTRATING THE PROCESS OF WELDING BOILER TUBES TO THE TUBE SHEET.

Carefully studying the boiler repair question, which resulted in placing a man in general charge of the maintenance of boilers and the issuing of permanent instructions concerning the exact way in which the boilers should be cleaned and washed, and seeing that they were enforced, almost did away with the ordering of stay-bolt iron on one railroad.—*American Engineer and Railroad Journal.*

METHOD OF APPLYING FLUES TO ENLARGED FLUE HOLES.

BY C. E. LESTER.

It is a well-known fact among railroad boiler makers, that, where the dry pipe is not removed when renewing a set of flues, or where a part set of flues is required to be renewed for any purpose between overhaulings of the locomotive, it is necessary to enlarge a hole, or holes, in the front flue sheet for transfer purposes. The hole is required to be enlarged from 1/8 inch to 3/8 inch, depending greatly upon the condition of the water in the territory in which the engine operates, and the consequent amount of scale and mud adhering to the flues.

When re-applying flues after these holes have been enlarged on all the roads with which I have been connected, the practice has been to apply a copper heavy enough to bring the holes down to normal, or if the size of the hole would warrant it, to apply a safe-end the next larger size, and set the flue in the front end by rolling.

It is the practice on the road with which I am connected to bead all flues in the front end, and we found in several cases that the flues in the enlarged hole would leak, and in two cases where the beads had got weak in the fire-box end that the flue in the enlarged hole blew out into the smoke-box on account of weak beads in the fire-box end, and the flue becoming loose in the front sheet, the steam pressure on the tapered part of the flue and on the bead had volume enough to blow the flue out. We immediately took steps to prevent any recurrence. The accompanying print, with note explaining it, was prepared and sent out and the following instructions issued:

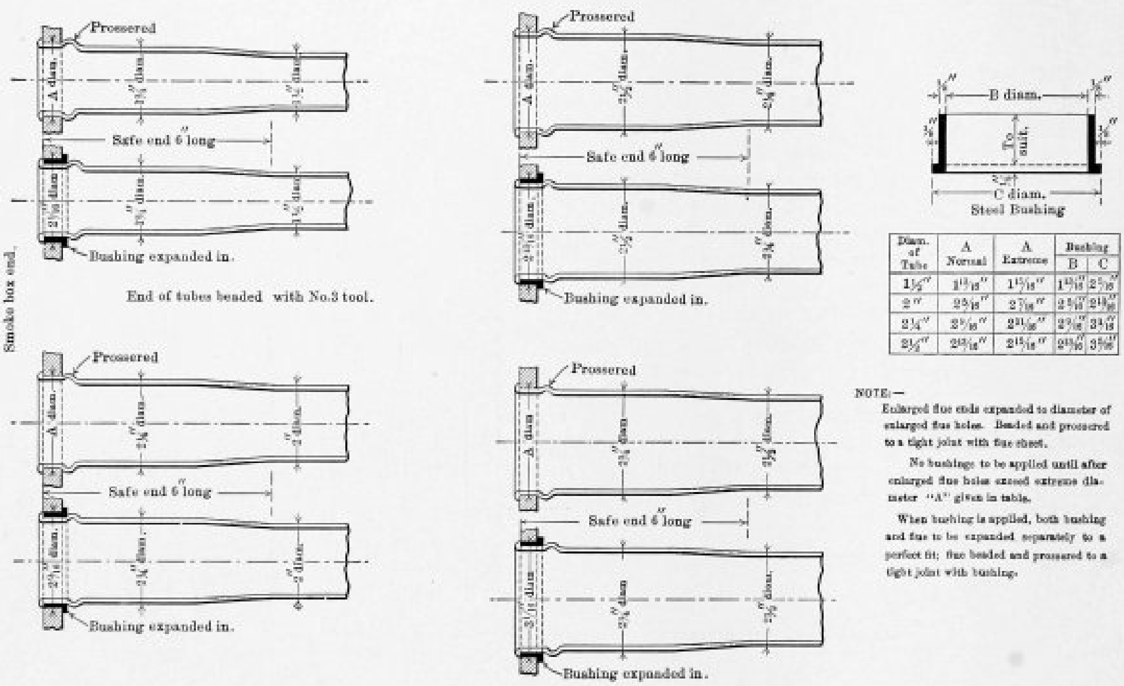
"When flues are applied to the large holes provided for transfer purposes, it is required that the following practice be observed in detail:

"A flue standard to the boiler is required to be used, and the end enlarged by welding thereto a safe end six (6) inches in length and one-quarter (1/4) of an inch larger than the nominal diameter of the flue prescribed to be used.

"The hole, or holes, in the front flue sheet to which the enlarged flue or flues are to be applied, are required to be increased in size, not less than five-sixteenths (5/16) of an inch, not more than seven-sixteenths (7/16) of an inch above the nominal diameter of the flue to be used.

"Provided that when an enlarged hole exceeding the extreme limit of seven-sixteenths (7/16) of an inch above the nominal diameter of the flue standard to the boiler already exists in the flue sheet, it is required to increase the same to nine-sixteenths (9/16) of an inch above the nominal diameter of the flue, and use a steel bushing as specified on card No. 11,476-B, or reissues of the same. The use of copper ferrules, or any other bushing than the one prescribed on card No. 11,476-B in connection with the enlarged end, is positively forbidden; and, further, the use of the bushing until the hole or holes exceed the extreme limit of seven-sixteenths (7/16) of an inch above the nominal diameter of the flue standard to the boiler is likewise forbidden. When the above specifications have been complied with the flue is required to be rolled in the sheet or bushing, and prossered and beaded strictly in accordance with card No. 5,369-D (standard flue setting) and card No. 11,476-B, or reissues of same."

This method of taking care of the enlarged holes has been rather expensive in a way, as steel bushings have to be furnished, additional cost per welding up and applying special flues, and special prosser expanders are required to prosser the flues in the front sheets. However, the safety of employees and the traveling public is the first thing to be considered, and this method, when consistently followed out, eliminates entirely any opportunity for accident by the flue in the enlarged holes blowing out, with probable loss of life and resulting damage suits. A systematic record is kept in the general mechanical superintendent's office and in the offices of the several master mechanics of the application of these special flues. The information consists of a record showing the number of enlarged flue holes and the date of application and re-application of special flues in these holes of every engine on the system.



Diam. of Tube	A Normal	A Extreme	Bushing B	Bushing C
1½"	1 11/16"	1 15/16"	1 15/16"	2 [illegible]
2"	2 3/16"	2 7/16"	2 5/16"	2 [illegible]
2¼"	2 7/16"	2 21/32"	2 9/16"	3 [illegible]
2½"	2 13/16"	2 15/16"	2 [illegible]	3 [illegible]

NOTE:—

Enlarged flue ends expanded to diameter of enlarged flue holes. Beaded and prossered to a tight joint with flue sheet.

No bushings to be applied until after enlarged flue holes exceed extreme diameter "A" given in table.

When bushing is applied, both bushing and flue to be expanded separately to a perfect fit; flue beaded and prossered to a tight joint with bushing.

DETAILS OF FLUES EXPANDED IN ENLARGED HOLES.

The average serviceable life of a locomotive in Great Britain is variously estimated at from twenty to thirty years. The annual expenditure per engine for renewals and repairs is about $1,150.

Development of an Irregular Pipe Connection by the Method of Tangent and Crossing Planes.

BY I. J. HADDON.

Fig. 1 shows how the job would look when finished if the thickness of material is disregarded. Fig. 2 is the half plan and elevation of the parallel pipe that is cut at a bevel, as may be seen in Fig. 1. Fig. 3 is the development of this pipe, the construction of which is so simple that the drawing explains itself, but there is one point I wish to impress upon your readers, which may be seen by the drawing, and that is, that the line *A-B*, Fig. 2, should represent the center of holes, and not the edge of the plate. The lap can always be added after the holes are correctly spaced.

You will no doubt notice I have made the seam of this pipe at the side. The reason I put it there was because at *A* and *B* the pipe would have to be bent, and it would make a better job if the seam was put at the side as shown.

Of course the seam could be put wherever desired, but I should prefer it here.

You will notice a dotted line in the elevation of Fig. 2. This has been shown in the development, so as to prove that triangulation in respect to curved surfaces is not a reliable method, for with *C* in Fig. 3 as a center, and *C-D*, Fig. 2, as a radius, describe an arc, as shown in Fig. 3. Now, if triangulation were accurate, the arc drawn would cross the center of the hole at *D*, Fig. 3, whereas it is inside the hole. Again, had the dotted line been drawn from *B* to *E* it would be found that the arc drawn in the development would be inside the hole *E*, Fig. 3 Therefore it does not matter which way you may draw the dotted lines to form triangles, they can never be correct in respect to curved surfaces.

The reason is, because the dotted line forming the triangle in the elevation Fig. 2 is in reality a curved line, and in the development this extra length to allow for the curvature is not taken into account, and it would be rather difficult to do so; hence the inaccuracies. I think I have said sufficient to stop anyone ever using triangulation again in respect to curved surfaces and saying they have made accurate work.

There is another point I might mention in reference to a pipe cut to a bevel. We will suppose the pipe Fig. 2 has got to be, say, 6 feet diameter, and the depth of rake or bevel from *A* to *F* is known, say 8 inches, as in the case of a main funnel, it is not necessary to put the plan and elevation down full size, because any size plan and elevation of a pipe will do just as well, the only thing is that the depth from *A* to *F* must be the required 8 inches.

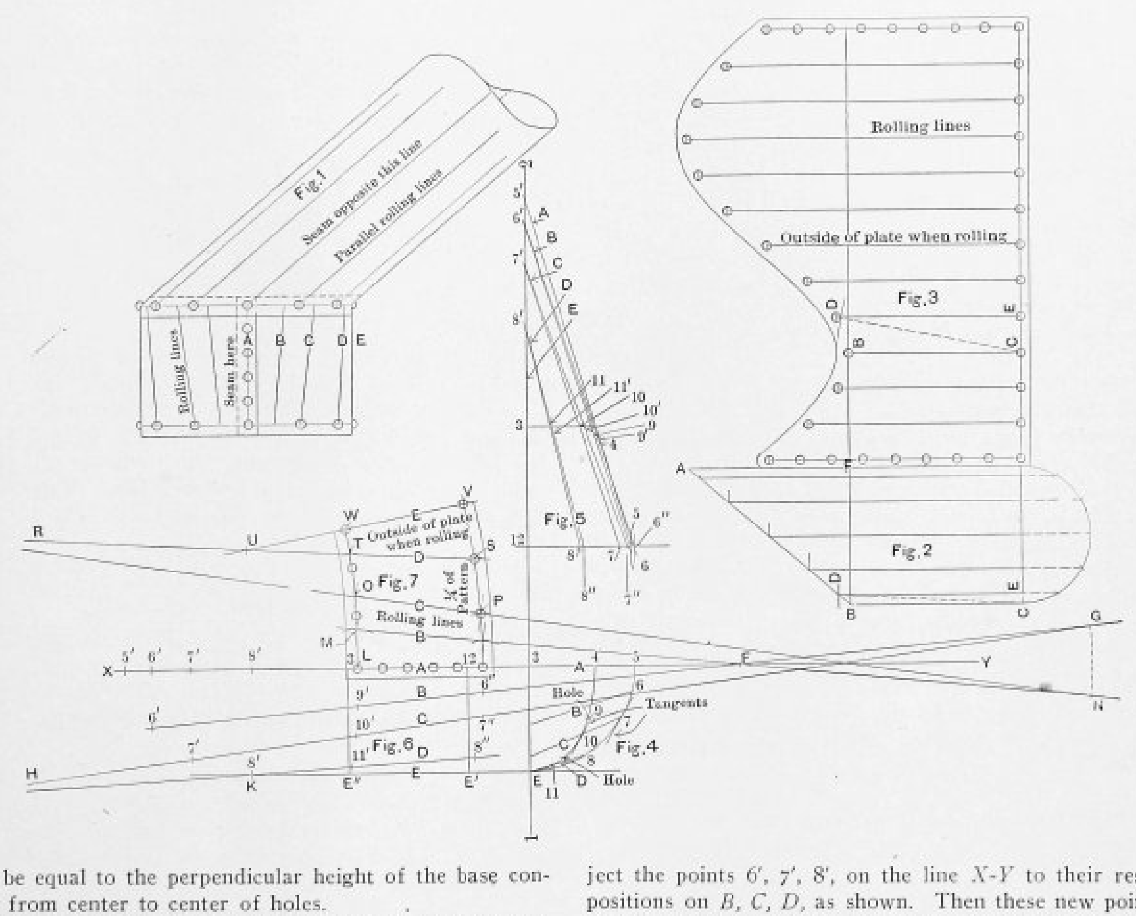
BASE CONNECTION.

Draw the line *X-Y*, also the perpendicular line 1-2. Construct the quadrant and the quarter ellipse, as shown in Fig. 4. These represent a quarter of the bottom and top of the base connection. 3-*E* should equal half the diameter of the circle, and 3-4 equal half the minor axis of the ellipse, of course 3-*E* will be one-half the major axis.

At any convenient distance from Fig. 4, and perpendicular to line 1-2, draw the lines 12-5 and 3-4, Fig. 5, 12-3; Fig. 5, 12 as center, Fig. 5, and radii equal to the length of the lines *B, C, D*, Fig. 4, cut the line, as shown in Fig. 5, in 6″, 7″, 8″, and connect the same to their respective points in the vertical plane, you will then have the plan, elevation, and true length of all the lines necessary for the development.

Now, we must get another view of the elevation so that we may see where the lines *B, C, D* (which are really cutting planes), touch the vertical plane, as at 5′, 6′, 7′, 8′, Fig. 5.

At any convenient distance from *E*-3, Fig. 4, draw the line *E*′-12, Fig. 6, parallel to *E*-3, Fig. 4. Then from 12 along the line *X-Y* mark the points 3, 8′, 7′, 6′, 5′ equal to the vertical heights shown in Fig. 5. Through *E*′, Fig. 6, draw a line parallel to *X-Y*; also draw the line 3, *E*″, parallel to 12, *E*′. Project the points 6, 7, 8, Fig. 4, to the line 12, *E*′, Fig. 6; also the points 9, 10, 11, Fig. 4, to the line 3, *E*″, Fig. 6. Draw lines through these points until they cross, as shown in *F, G, H, K*, these lines we will call *B, C, D*, as shown. Pro-



should be equal to the perpendicular height of the base connection from center to center of holes.

Connect 5-4 and produce the line until it cuts the line 12-2, as shown in 5′. Now, it will be necessary to show the rolling lines in the plan Fig. 4. As the top and bottom of the base connection are parallel, the tangents that I am about to explain will be parallel.

Divide the quadrant Fig. 4 into any number of parts, not necessarily equal, as 6-7-8, and draw tangents to each point. Then draw tangents to the ellipse parallel to the ones drawn to the circle. Now, where the tangents touch the circle and ellipse, connect the points, as shown by lines *B-C-D*, and produce them until they cut the line 3-*E*, these will be rolling lines. Now, project the points 6-7-8 to the elevation, as shown in Fig. 5, also the points 9-10-11. Then draw lines through these until they cut the line 12-2 in 6′-7′-8′, this in reality is where the lines meet the vertical plane 1-2.

Now, we must obtain the true length of these lines, so with ject the points 6′, 7′, 8′, on the line *X-Y* to their respective positions on *B, C, D*, as shown. Then these new points will show the position where the planes *B, C, D*, Fig. 5, meet the vertical plane 12, 2.

Now, from 5′ on the line *X-Y*, and with a radius equal to 5′, 5, Fig. 4, cut the line *X-Y*, which will be our first hole in the pattern, and with radius 5′, 4, cut the line *X-Y*, which will give us the hole marked *L*.

Now, with 6′, 7′, 8′, Fig. 6, as centers, and 6′-6″, 7′-7″, 8′-8″, Fig. 5, respectively, as radii, cut the lines *B, C, D* in the points 6″, 7″, 8″, obtain the points 9′, 10′, 11′, Fig. 6, in a similar manner.

TO DEVELOP THE PATTERN.

The plane *B*, Fig. 6, crosses the plane *X-Y* in *F*, so with *F* as a center and radii, *F* 6″, *F* 9′, draw the arcs as shown in the development, then with radius equal to the distance 4-9, Fig. 4, and from the center of the hole *L* cut the arc drawn from 9′ in *M*. Through *M F* draw a line, which will also cut the arc drawn from 6". This line B is a rolling line, and represents B in the plan and elevation. When drawing this line, it should be extended well beyond the point F, as shown.

Now, the plane C, Fig. 6, crosses the plane B in G, so with F as a center and $F\ G$ as a radius, draw the arc as shown, cutting the developed line B in N. Now with N as a center, and G 7", and G 10' as radii draw the arcs as shown in the development. Now, with M in the development as a center, and 9 to 10, Fig. 4, as a radius, cut the arc in O. Through $O\ N$ draw a line cutting the other arc in P. This line is the development of the line C and is also a rolling line. When drawing this line it should be well extended in the opposite direction, because the plane D, Fig. 6, meets the plane C on the opposite side of the figure to $G\ N$.

Next, with radius 10'-H, Fig. 6, and center O in the development, cut the developed line C in R. Then with R as a center, and H-11' and H-8" as radii, draw the arcs as shown. Now, from P in the development, with the distance 7 to 8, Fig. 4, as a radius, cut the arc in S, draw a line through $S\ R$, cutting the other arc in T. This will then give the development of the line D and is also a rolling line.

With R as a center, and $H\ K$, Fig. 6, as a radius, cut the line $R\ S$ in U. Now, with U as a center, and with $K\ E''$ and $K\ E'$, Fig. 6, as radii, draw arcs as shown, then with center S and radius equal to the length from 8 to E, Fig. 4, cut the arc in V, join $V\ U$, cutting the other arc in W, this will then give the developed line E. Draw fair curves through W, T, O, L and V, S, P, and we will then have the center line of holes, which will be one-quarter of the pattern. Now, this being a flat surface it is an easy matter to develop the whole pattern from this by triangles. I do not think that needs any explanation.

As regards the holes, the points 7 and 8, Fig. 4, divide, in this case, the quadrant into three parts, therefore P and S are those points in the development, and as there are twelve holes in the parallel pipe when finished, all it is necessary to do is to project the points 7 and 8, Fig. 4, on to the elliptic curve parallel to the line $X\ Y$ as shown; these points represent the holes at the top, so that all you have to do is to transfer those points to the development, measuring from 4 to E, Fig. 4, and L to W in the development. Allow the necessary lap on to complete the development of the quarter pattern. In this drawing the points R and H are not shown, but their position may be readily found if desired.

SIMPLE RULES FOR FINDING THE CAPACITIES OF TANKS.

BY JOHN COOK.

The following simple rules will enable sheet-iron workers to figure the capacities of tanks of different shapes. It is well known that a great many young men working at the sheet-metal trade do not understand how to figure out the capacity of a tank, or the area of a stack or pipe, and if a customer comes in who wants a tank built to hold one barrel of oil or water, the outside diameter being limited to, say, 16 inches, they are at a loss as to how to proceed.

The problem just stated can be solved by reducing the contents of a barrel to cubic inches and dividing the result by the area of a 16-inch circle. One barrel is supposed to contain 31½ gallons, and in a gallon there are 231 cubic inches. Multiplying 31½ by 231 we get 7,276.5 cubic inches. The area of a 16-inch circle is 201.06 square inches. Therefore, dividing 7,276.5 by 201.06 we get 36.19, or, say, 36⅛ inches as the height of the tank.

Again, assuming the tank to hold the same quantity, and desiring that the height shall be 40½ inches, what must the diameter be? In this case divide the number of cubic inches, which the tank contains by the height, giving the area of cross-section, and divide this by .7854. Then extract the square root of the quotient, which will give the desired diameter. As we have found that there are 7,276.5 cubic inches in 31½ gallons, we will divide 7,276.5 by 40.5, giving 179.66 square inches as the area of the cross-section of the tank. 179.66 divided by .7854 equals 228.75. The square root of 228.75 is 15.124, or 15⅛ inches, the desired diameter of the tank.

For the next problem, assume that we have a tank to build 8 feet square and 8 feet high. The rule is to multiply the length of any one side by its adjoining side, and that product by its height. In this case $8 \times 8 = 64$, and $64 \times 8 = 512$ cubic feet. As there are 1,728 cubic inches in one cubic foot, there will be $1,728 \times 512$, or 884,736 cubic inches in the tank. Dividing this by 231, the number of cubic inches in a gallon, we find that there are 3,830 gallons in the tank. This result can also be obtained in another way. Since there are 7.48 gallons in a cubic foot, we can multiply 512 by 7.48, obtaining 3,829.76 gallons.

Supposing a customer wished to have a round tank built, 8 feet in diameter and 8 feet high, and wished to know how many gallons it would contain. We would square the diameter and multiply that by the height, and that product by 47, and then divide by 8.

$$8 \times 8 = 64$$
$$64 \times 8 = 512$$
$$512 \times 47 = 24,064$$
$$\frac{24,064}{8} = 3,008$$

A short method may be used for solving this last problem as follows: A cylindrical foot, that is, the volume of a solid 1 foot diameter and 1 foot deep, is 78.5 percent of a cubic foot and contains 5⅞ gallons, so that 512 cubic feet can be multiplied by 5.875, giving 3,008. Or it may be still easier to multiply by 6 instead of 5.875, and then diminish the result by ⅛ of 512. Following out this rule we have:

$$512 \times 6 = 3,072$$
$$\tfrac{1}{8} \text{ of } 512 = 64$$
$$\text{Therefore, } 3,072 - 64 = 3,008.$$

Some Points on the Boiler Blowoff.

The boiler blow-off has two purposes to serve, viz.; to drain the boiler of water when necessary, and to discharge the mud and sediment that accumulates from the feed-water. In connecting up a blow-off pipe every precaution should be taken to avoid weakness and stoppages. This is one of the most dangerous fixtures in a boiler room. In the first place, decide upon some method of protecting the pipe inside the combustion chamber, and at any other point where it will be exposed to the heat of the gases. This heat will bake the sediment and scale inside the pipe, which, in turn, will cause the pipe to burn. An effective and convenient way is by slipping a sleeve over it, although walling it in with brick is no doubt preferable. After getting the pipe through the wall, the blow-off valve or cock is put on. For safety it is desirable to use a valve, and a cock as an auxiliary. By placing the cock between the boiler and the valve, in case the valve should fail to shut off properly on account of scale or sediment getting into the seat, the cock may be closed and the valve taken down and the seat reground. By using a valve the pipes and boiler are not given a sudden shock or strain, as it opens and closes gradually, while with cocks or gate valves the conditions are quite the reverse.—H. E. Atherton in *The Southern Engineer*.

THE MANUFACTURE OF SHELBY SEAMLESS STEEL TUBES FROM BILLETS.

The steel for Shelby seamless steel tubes is shipped to the rolling mills in blooms 7 inches square in section, and about 6 feet long, weighing, approximately, 750 pounds each. Before being rolled, each bloom is carefully inspected for surface defects, and all irregularities are chipped off with pneumatic hammers. The blooms are then sent to the heating furnace, and after acquiring a suitable temperature are rolled from their square section to round bars, which vary in diameter according to the size of tubes required to be made from them. Some of the bars are 6 inches in diameter when finished; others are as small as 2½ inches. For convenience in shipping, they are cut to lengths of about 10 feet, and sent to the various tube mills on factory requisitions.

The piercing machines at each mill have different capacities, in sizes and quantities; the "rounds" must therefore be cut again into pieces which will furnish with the least waste the size, length, and thickness of tube required by the factory's orders. After being cut to the working length the steel is known as a billet. It may be from 1 to 5 feet long; but it must contain as many cubic inches of steel as the finished tube, plus enough to cover the loss incidental to manufacture.

It is important that the piercing point should strike the very center of the solid billet as it advances, for if it does not, the steel will be thicker on one side of the finished tube than on the other, and no amount of careful cold-drawing can correct the eccentricity. To insure the passage of the point through the center of the billet, each one is drilled suitably before it passes to the heating furnace. The bottom of the furnace is inclined, and the centered billets of the proper length are fed into the upper and cooler end, from which they roll by gravity to the lower end, where the temperature is high enough to render the steel soft and semi-plastic. Close to the discharging end of the furnace the piercing mill is located, and the billets are fed into it, centered end foremost, either automatically, or, in the smaller mills, by hand.

The solid billet, almost white hot, is pushed forward until it is caught by the revolving piercing disks, and from that point onward the machine completes the operation without the touch of a human finger. When the billet reaches the stationary piercing point of malleable iron, and starts to pass over it, forced by the forwarding and revolving action of the heavy rotating disks, only a slight, dull, grinding sound is audible; there is nothing spectacular about the operation, nor much suggestion of the enormous power required to displace the metal from the center of the hot billet towards the outside. So powerful are the piercing disks and so carefully planned is each part of the massive machinery that the billet is apparently molded into a tube with the same freedom as a lump of dough is manipulated by a pastry-cook. When the tube emerges from the machine, hot gases burn lividly from its ends; the inspectors look over it carefully for possible defects, and if it is perfect it is rolled at once to the saw, which cuts it in two pieces almost instantly; a shower of sparks and a ringing noise accompany the operation.

The newly pierced billet is simply a rather rough, thick-walled, scaly, seamless tube. It is raw in appearance and not particularly true to size, and it retains the corrugations of the piercing disks on its battled surface. But it is positively without a seam or weld, the round bar of steel having been pierced quite through its length, as a potter would force a pointed rod through a cylinder of moist clay. It is short, because most of its substance is yet in its walls, and to change thickness into length is the next requirement. Accordingly the tube is passed once more to a heating furnace, and at the proper temperature it is rolled over long, round bars of tool steel, through grooves successively smaller, and in this manner converted into a long, thin-walled tube with a fairly smooth surface finish.

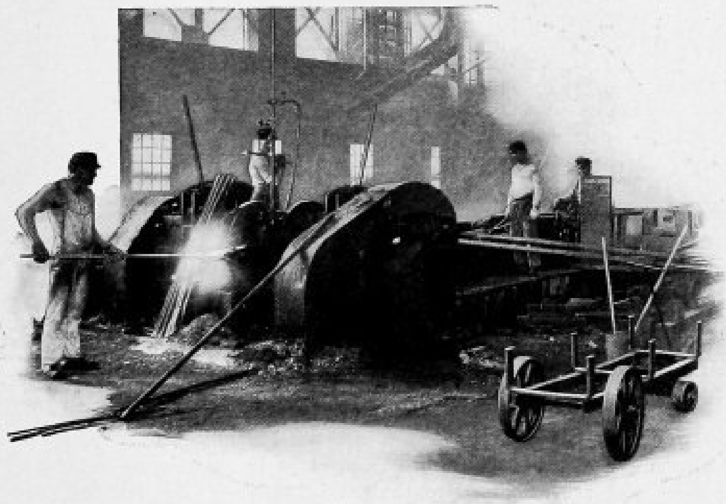


FIG. 1.—HEATED BILLET ENTERING PIERCING MILL.

Even now it is only a hot-rolled tube, and lacks accuracy in diameter, gage, and rotundity. One more operation, known as "pointing," is needed to make it ready for the bench room, where it will earn by slow, careful, and exact manipulation, the distinguishing qualities that result from being cold-drawn. "Pointing" consists in hammering the heated end of each tube into a solid point, which can be caught by the heavy tongs of the drawbench in which the tube is to be cold-drawn.

Before tubes can be cold-drawn they must be clean and free from scale. They are therefore pickled in an acid bath, which is heated and kept in constant agitation by jets of steam.

The operation of cold-drawing is extremely simple in principle, and not in any manner new. It is practically the same for steel tubes as it is for brass and copper. All that is necessary is strong machinery and enough power to move it. The benches are substantially built of steel, and each is furnished with a heavy, square-linked chain, which runs over a wheel placed just underneath the die. This chain extends along the bed of the bench, for from 15 to 40 feet, to a sprocket.

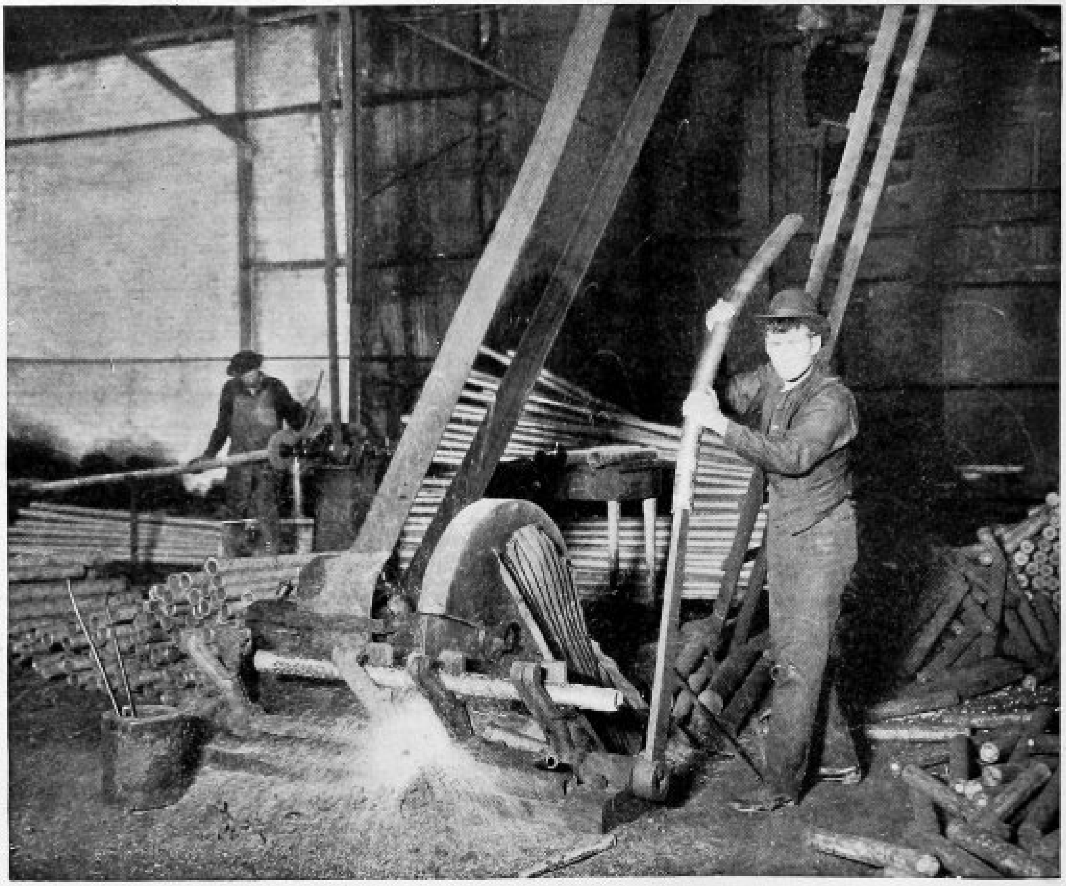


FIG. 2.—SAWING A PIERCED BILLET.

which is geared to the main shaft from the engine, and it returns underneath the draw-bench. Dies are made from the very best grade of crucible steel, and are machined to the thousandth of an inch, to govern the outside diameter of the tube which is to be drawn. All tubes, except those smaller than ½ inch inside, are drawn over a mandrel. This mandrel is kept in position by a long bar, which goes inside of the tube and holds the mandrel just even with the die while the tube is being pulled.

The drawing operation hardens the metal and makes it

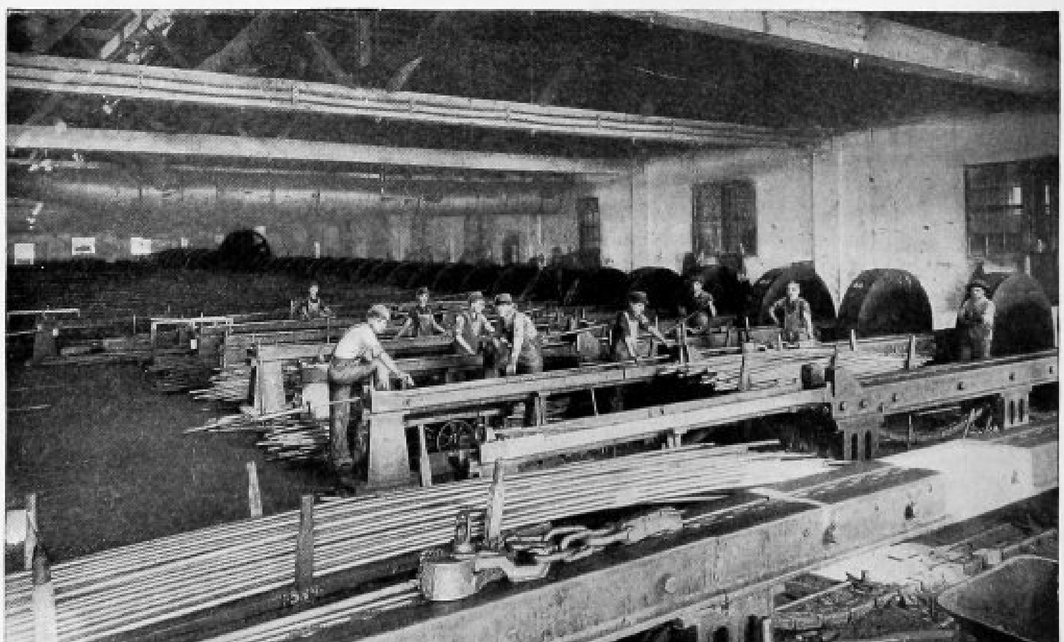


FIG. 3.—THE COLD DRAWING BENCHES.

necessary to anneal every tube before it can be drawn again. It must be remembered that it may require from two to twenty passes through dies of varying diameter to produce a tube with the required dimensions. Such a tube must be annealed after each pass, to eliminate all the brittleness of the steel which resulted from previous cold-draw passes and to permit further drawing.

The process of annealing is attended with the formation of scale; and, from the remark made in a previous paragraph, this necessitates a return of each tube to the pickle-bath each time it is annealed. The intermediate anneals, or anneals between bench-passes, are made in open furnaces; but for the consumer, tubes are annealed to the buyer's specifications.

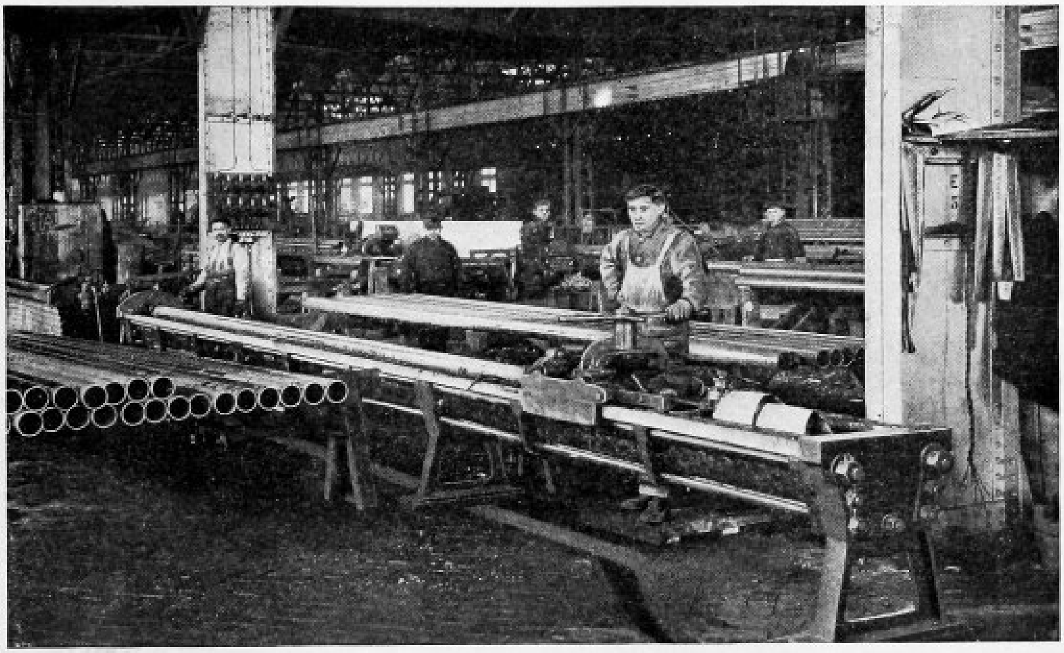


FIG. 4.—TESTING BOILER TUBES.

The "points" of the tubes remain until after the last pass through the dies, which brings the tube to the desired outside diameter and thickness; then, after the requisite anneal has been given, the tube passes to the cutting-off machines, where it is either cut to specified length or multiples, or cut to the best advantage in random lengths. Boiler tubes are tested by hydrostatic pressure, but the mechanical tubes are not so treated.

Flue Leakage.

In a recent bulletin the International Railway Congress discussed the causes of the leakage of locomotive boiler tubes, bringing out the following points. It is first shown that care in executing the work of setting the tubes has only an influence of secondary importance, whereas the more important reasons for flue leakage are the expansion and contraction phenomena, unequal variations of temperature and incrustation:

In order to prevent leakage at the tubes some companies, in addition to the usual precautions, as to the management, the maintenance and the washing of the boilers, have tried special arrangements.

The French Northern has tried expansion smoke tubes, the front ends of which pass through a stuffing-box fixed to the smoke-box tube plate. But the use of such stuffing-boxes, even if they allow the tubes to expand, does not remedy the loosening which results from the transverse expansion of the tube plate of the fire-box. This trial has not been extended. Then, also in a number of its more recent locomotives, the French Northern has placed the end of the feed-water pipe in the steam.

The Midi is at present trying to prevent the leaks by sending the feed-water into a tank placed above the level of the water and in the front of the boiler. Several French railways, in order to reduce the giving of the interspaces and the ovalization of the tubes, which nearly always begin at the upper corners of the fire-box tube plate, reduce the diameters of the tubes placed there, so as to increase the magnitude of the interspaces. The Italian State is at present trying the use of an injector of reduced size, capable of supplying water continuously, the preliminary heating of the feed-water and the installation of the Goldsdorf water-softening apparatus, which consists of a flattened box, placed vertically between the barrel and the nest of tubes in which the feed-water pipe ends.

It may be remarked that it is not, as a rule, necessary to adopt injectors of reduced size in order to insure a continuous feed, for with the modern restarting injectors of the usual size the amount of water given may be varied from normal to practically double by adjusting the water valve. It would be eminently desirable to give the feed-water a preliminary heating either by means of the exhaust gases or of the smoke-box gases; various attempts in this direction have been made or are being made; unfortunately, the appliances required for the purpose are very complicated, and no good solution of the question has at yet been obtained.

The effect of soot on the evaporation of a horizontal tubular boiler is shown by some trials made in which during the first series soot was allowed to remain on the tubes and in the second series the tubes were cleaned in the morning. With the soot allowed to accumulate the evaporation from and at 212 degrees per pound of dry coal was 6.2 pounds, the dry coal per square foot of grate surface 13.4, and the temperature of the escaping gases 627 degrees F. With the tubes cleaned, the evaporation from and at 212 degrees per pound of dry coal was 7.04 pounds of water, the dry coal per square foot of grate surface per hour was 9.09 pounds, and the temperature of the escaping gases 546 degrees.—*Practical Engineer.*

The Boiler Maker

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NOTICE TO ADVERTISERS.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

Triangulation.

A correspondent this month questions the accuracy of triangulation as a method for laying out irregular-shaped plates in sheet metal work. His criticism is based on a problem which was published a short time ago in THE BOILER MAKER, describing the layout of an irregular transition piece, the solution given being by the method of triangulation. It is pointed out that the true lengths of lines, as determined for the pattern, do not represent accurately the lengths of the lines as they appear on the surface of the solid, and it is claimed that this difference between the actual length of a line on the surface and the length of an imaginary straight line, which is used in the development of the surface, is sufficient to cause a serious error in the pattern if this system is used.

In developing a curved surface by triangulation, as is well known, the method of procedure is to divde the surface into a series of adjacent triangles, and then by finding the true length of each side of the triangles to lay out the pattern with the triangles in their proper relation one to the other. In dividing a curved surface into triangles, however, it is obvious that it is impossible to draw a straight line on a curved surface unless it is a generating line; that is, a line along which a plane could be placed tangent to the surface. Therefore, since the lines which form the triangles on the surface are actually curved lines, they will obviously be longer than the imaginary straight line connecting the points which they join. It is the imaginary straight line of which the true length is found, and which is used in the development of the pattern; thus the true lengths of the lines used in the pattern are always slightly shorter than the actual lengths of these lines on the surface when it is rolled up or formed to the proper curvature. This difference in length our correspondent considers to be too great an error to admit of accurate work in laying out, and he says that practical boiler makers would never think of using triangulation and expect to obtain the necessary degree of accuracy.

Our correspondent is perfectly correct in his statement pointing out the error which exists in the method of triangulation. We believe, however, that he greatly over-estimates the magnitude of this error. In the various problems in laying out which are published in THE BOILER MAKER, the figures are necessarily small, and, in order not to produce a confusion of lines, the surfaces are divided into only a small number of triangles. Thus we have curved lines developed where the length of the curved line differs quite appreciably from that of the imaginary straight line which it is supposed to represent. In actual work, however, on a large scale, the surface would be divided into a great many more triangles than are shown in the illustrations, and consequently the curvature of the lines is very slight indeed; so slight, in fact, that the error due to the difference in length between the curved line and the imaginary straight line connecting its extremities is inappreciable for all practical purposes. Therefore the apparently large error which exists in the problems, when worked out with only a few triangles for the purposes of demonstration, disappears when it comes to the actual work in the shop.

Fortunately, our correspondent does not condemn triangulation without offering another method to use in place of it. The method which he suggests involves finding the true length of straight lines on the curved surface, or lines which are formed by the intersection of the surface with tangent planes. These lines are not taken arbitrarily, but a sufficient number of them is used to divide up the pattern into a suitable number of divisions. Granting that the true length of these lines is obtained by the method described, as it should be if the work is carried out carefully, it should still be remembered that the curved lines forming the edges of the plate are laid out by taking off spaces with dividers, and, consequently, the length of the spaces would be the length of imaginary straight lines connecting points on the curve, so that the true length of these edges is no more nearly correct than when triangulation is used. As we have already pointed out, however, the error in such work is inappreciable, and, of course, this applies to the method suggested by our correspondent as well as to the method of triangulation. It is simply necessary to know that the objection which applies to one method exists in the other also.

We do not say this in condemnation of the new method proposed, but simply to call attention to the fact that triangulation is sufficiently accurate for all practical use, and can be made extremely accurate if the surface is divided into a sufficiently large number of triangles. Triangulation, however, has the advantage of being a simple method, one easily understood and one which is universally applicable.

COMMUNICATIONS.

A Condemnation of Triangulation for Developing Curved Surfaces.

EDITOR THE BOILER MAKER:

I am greatly interested in the problems given in THE BOILER MAKER, especially the developments, or layouts, as you generally term them, but I cannot help noticing what a hold the system of triangulation has upon your contributors. I am almost inclined to believe that they cannot be practical men, as any problem in curved surfaces that is developed by triangulation cannot be done accurately, and if the authors of these articles were practical men they would in practice soon find it out.

Now, Mr. C. B. Linstrom, in your issue for October, 1909, says in the last part of his article, page 274:

"It should always be borne in mind that accuracy is the main requisite in problems of this character, and if care is not exercised, especially where so many lines are involved, the pattern will be wrong, which will involve an unnecessary cost in both material and labor."

I quite agree with those remarks, but as regards the accuracy of triangulation with curved surfaces, I would advise Mr. Linstrom to work this same problem out again, but forming his triangles with the dotted lines thus—1-*F*, 2-*E*, 3-*D*, 4-*C*, etc.—and see if the patterns are the same. I venture to say they will not be, and if not, which method is correct, if either?

I might also point out that the pipe 1-*a*-*G*-1 is a parallel pipe cut to a bevel. Now, I will give him the credit of knowing the correct way to develop this, as this is so very easy, viz., by unrolling by parallel lines. He will then find that in the development *A*, *B*, *C*, *D*, *E*, *F*, *G* is a straight line, whereas in his development by triangulation a curve is shown *A* to *D* and from *D* to *G*. I think that should convince anyone that triangulation, in respect to curved surfaces, cannot be relied upon.

Now, as regards the base connection, Mr. Linstrom says, on page 274:

"As the operation of constructing this portion of the layout is comparatively easy, it will need no further explanation."

No doubt it would be easy enough if triangulation could be relied on, but as it cannot, we must resort to other methods that can.

Now, the method I have adopted for the solution of this problem is one involving the use of tangent and crossing planes to curved surfaces. I may say here, that all of the problems with curved surfaces that have been solved in THE BOILER MAKER by triangulation have been inaccurate, but they could have been solved accurately by the method of tangent and crossing planes to curved surfaces. I say this notwithstanding the fact that so many writers in THE BOILER MAKER have advocated the use of triangulation.

It should always be the aim in layouts to have straight lines in the plan and elevation, and these lines should become rolling lines in the development. Now, the parallel lines in the elevation of the base connection, as shown by Mr. Linstrom, are, in reality, curved lines, because they are not rolling lines. As regards the pipe cut to a bevel, the lines shown there are correct, and being parallel, it is only a matter of what may be termed unrolling the pipe, when, of course, the line *A*, *B*, *C*, *D*, *E*, *F*, *G* is a straight line, and the true length of each line is shown in the elevation.

I might also point out that, where the pipe connects to the base, the line 1, 2, 3, 4, 3, 2, 1, should be the center of holes, and the lap allowed on afterwards.

I sincerely hope that my very pointed remarks in reference to the inaccuracy of triangulation will be taken in the good spirit in which they are given.

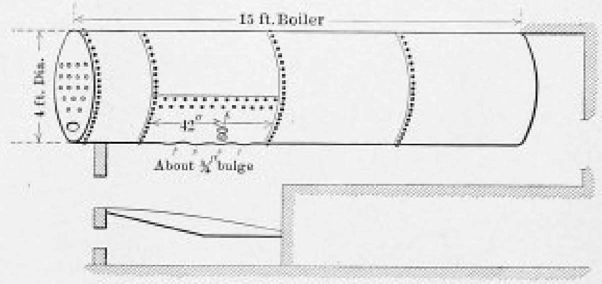
Many of the problems involving triangulation which are published in THE BOILER MAKER are republished in the *Mechanical World* in England and in other papers, and it seems important that the inaccuracies of this method should be thoroughly appreciated. I. J. HADDON.

Cardiff, Wales.

What is the Cause of the Bagged Patch?

EDITOR THE BOILER MAKER:

We would like to see some discussion on the inclosed sketch, and perhaps some brother boiler maker can suggest the cause of the trouble. There were two return tubular boilers about 20 years old, similar to that shown in the sketch on which we placed bottom patches at the furnace end. Each patch was 60 inches long by 42 inches wide, the rivets in the longitudinal seams were 2 inches pitch and staggered, the girth seams were single riveted, with a 2-inch pitch. The rivets were ¾ inch, and the plate 5/16 inch, of 60,000 pounds tensile strength. About four days after the first patch was put on, the bottom came down without any apparent cause, as shown in the sketch. Instead of the patch pulling at the girth seams, we found, upon cutting out some of the rivets, that the metal had gone the other way, there having been a tendency for the plate to push out instead of pull in at the joints.



SKETCH SHOWING LOCATION OF BAGS IN PATCH.

On the other boiler extra precautions were used, on account of the bagging of the first patch, but after the second boiler had been in operation about a week the same thing happened as on the first one. It was claimed that there was no grease in the boiler, and that low water did not occur.

W. & T.

TECHNICAL PUBLICATIONS.

Steam Power Plant Piping Systems. By William L. Morris, M. E. Size, 6 by 9 inches. Pages, 490. Figures, 389. New York, 1909: McGraw-Hill Company. Price, $5.00 net.

The subject matter of this book is the result of the author's personal experience in the design of piping systems for steam power plants, and the subject is discussed solely from his point of view. This does not mean, however, that the book lacks breadth or completeness, for the author has had a wide and varied experience and is amply qualified to write as an expert on his subject. In fact, the results of the study and work of a specialist are here presented in such form that the average engineer can profit by them. The design of boilers and engines is not touched upon, but all auxiliary apparatus in the pipe circuit between the boiler and engine and in the various piping systems for steam, oil, air, etc., have been treated and their general design discussed.

The author points out that the chief requisite in pipe work engineering is to so design as to permit repairs of disabled lines without interfering with the regular service of the plant. This he suggests can best be accomplished by allowing the pipe fitters and manufacturers to design the details of the piping, a part of the work which the engineer himself is seldom capable of doing to the best advantage, and for which he can rarely afford to employ specialists. It would then devolve upon the piping contractor to design the details, and the responsibility for good pipe design would then be fixed, for the contractor's reputation would depend upon his design as well as upon his workmanship. The engineer could then devote his entire time to getting out complete piping system diagrams, and so designing the complete arrangement as to meet the chief requisite for good pipe work mentioned above, work which he is or should be qualified to do. This method deserves thorough consideration, for it evidently has much to recommend it.

The Prevention of Industrial Accidents. By Frank E. Law and William Newell. Size, 5 by 7¾. Pages, 104. Figures, 72. New York, 1909: The Fidelity & Casualty Company, of New York. Price, 25 cents.

This is the first pamphlet of a series which the Fidelity & Casualty Company, of New York, are to publish on the subject of the prevention of industrial accidents. This pamphlet is general in its nature, and contains chapters on Care on the Part of Employers and Employees, Safety Devices, Steam Boilers, Engines, Electrical Apparatus, Elevators, The Factory, and Woodworking Machinery. Due to the nature of its work, this company is, of course, well qualified through its staff of experts to approach this subject in a thorough and complete manner, and the recommendations in the book are the result of observations and studies of industrial accidents made in this way. The recommendations are general in nature, and refer to those precautions which can be applied generally in all industries. It is claimed that many of the recommendations which are made may be carried out at small expense, although it is pointed out that where the recommendations are apparently costly, it would be well to bear them in mind when making replacements and renewals.

Official Proceedings of the Third Annual Convention of the International Master Boiler Makers' Association. Size, 5¾ by 8¼. Pages, 218. Numerous illustrations. New York, 1909: Harry D. Vought, secretary.

Since the formation of the International Master Boiler Makers' Association, the work of the organization has been placed before the public each year in a volume containing a complete report of the proceedings of the annual convention. This year's report contains also a complete list of the officers of the association, the committees which have in charge special topics for consideration at the next convention, and a list of all the members of the association. The proceedings of the third annual convention of the association were full of interest for every boiler maker, and none should fail to get a copy. Carefully worked-up and exhaustive committee reports on the following subjects are given in the proceedings, together with complete discussions of these topics by other members of the association: "Boiler Rules and Formulæ," "Standardizing Shop Tools and Equipment," "Standardizing Pipe Flanges," "Which is the Long Way of the Sheet?" "Boiler Explosions," "Bracing Crown and Flue Sheets," "Care of Flues and Tools for Same," "Steel vs. Iron Flues," "Present Method of Applying Brick Arches," "Flexible vs. Rigid Stay-bolts," "Standardizing Blue Prints," "Welding of Side Sheets and Cracks."

PERSONAL.

JACOB HALTER has been appointed master boiler maker of the Delaware & Hudson, at Oneonta, N. Y., vice Floyd Harris, resigned. Mr. Harris held the position of master boiler maker of the Delaware & Hudson for twenty-eight years, and was forced to resign only on account of ill health.

J. NICHOLAS has been appointed chief boiler inspector of the Cincinnati, Hamilton & Dayton, with headquarters at Lima, Ohio. Mr. Nicholas was formerly master boiler maker of the Chicago, St. Paul, Minnesota & Omaha at Sioux City, Ia.

Steam has been purchased from the Gage Publishing Company by the Ferguson Publishing Company, 114 Liberty street, New York. The Architects' and Automobile editions of *The Buyers' Reference* have also been purchased by the Ferguson Publishing Company.

LUCAN JOURDONAR, M. B. M., has accepted a position as layer out for the Anaconda Foundry Company, Anaconda, Mont.

G. S. PARVIN, formerly layer-out at the Cook works of the American Locomotive Company, Paterson, N. J., has been appointed foreman boiler maker of that shop, vice E. W. Rogers, transferred to the Rogers works of the same company.

QUERIES AND ANSWERS.

Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—What colors correspond to various degrees of heat in the fire-box of a locomotive boiler?

A.—Assuming that the question refers to the color of the steel itself, the following may be found approximately correct:

977 degrees F., incipient red.
1,292 degrees F., dull red.
1,472 degrees F., incipient cherry red.
1,652 degrees F., cherry red.
1,832 degrees F., clear cherry red.
2,021 degrees F., deep orange.
2,192 degrees F., clear orange.
2,372 degrees F., white.
2,552 degrees F., bright white.
2,700 to 2,900 degrees F., dazzling white.

Q.—If the crown bolt heads are found to have become dark blue after low water has occurred, what is the probable temperature to which they have been heated?

A.—They must have been heated to at least 570 degrees F., which is the temperature at which that color appears on steel when heated in air. It may be that they were heated to a greater temperature than this, although that cannot be determined.

Q.—In putting the first test on a locomotive boiler, the rivets in the first connection, or course, all leaked enough to require calking, while in the second course none of the rivets leaked. All of the rivets were of tht same size (1 inch), and the same style of rivet was used. All rivets were driven by hydraulic pressure. How much stronger would you expect the rivets in the second connection, or course, to be, or, in other words, how much stronger is a rivet that does not leak than one that does?

A.—If the rivets leak, it must be that they do not fill their holes completely; consequently it is probable that the cross-section of the leaky rivets is not quite as great as that of the tight rivets. There is no practical way of telling just how much stronger the tight rivets would be, if any.

Q.—Which is the better test to use to show the defects in workmanship in a boiler, steam or air pressure?

A.—There is a slight advantage in using steam, since it heats the metal in the boiler so that actual working conditions are more nearly attained.

Q.—If a portion of a boiler sheet is to be cut out and that portion extends to one of the circumferential joints, how should it be cut out and how should the patch be put on and made tight at the circumferential joint?

A.—A square section of the defective sheet may be cut out, or a section cut on a curved line. The patch, of course, should always be placed on the inside to avoid forming a pocket; and the corners of the old sheet, if it comes between the two other thicknesses of metal at the circumferential seam, should be scarfed out, so that the patch may be laid up smoothly and easily calked.

Q.—Why are patches sometimes made diamond shape?

A.—Patches are sometimes made diamond shape in order to obtain diagonal seams, which are stronger than seams parallel to the axis of the boiler. Since the patch frequently comes in way of the fire, it is necessary to make the lap where there is a double thickness of plate as narrow as possible, and hence only a single row of rivets can be used. By using the diagonal seam, which is possible with a diamond-shaped patch, a higher percentage of strength can be obtained for the joint than would be possible with a square patch.

Q.—Why cannot a boiler plate be upset and made thicker at the edges so that after punching out the rivet holes an efficiency of 100 percent can be obtained as compared with a solid plate?

A.—Theoretically, there is no objection to the above scheme, except the mechanical difficulty of upsetting the plate, and the consequent removal of stresses by annealing, etc. There is an added objection to the single-covered strap, in that such a joint forms a bent tie, which, due to the repeated expansion and contraction of the boiler plates, would be likely to cause fractures similar to those which develop in lap-jointed seams.

Q.—Is not the coefficient of expansion practically the same for iron and steel?

A.—Values for the coefficient of expansion are as follows: For wrought iron, .00000648; for steel, .00000689.

Q.—What is the objection to using a wrought-iron blow-off nipple on a steel boiler when a brass bushing is commonly screwed into the head for the feed pipe? Since brass has a different coefficient of expansion than iron, why do leaks not appear around the threads of such brass bushings?

A.—The question of what material shall be used for boiler mountings and fittings must be decided almost entirely by the rules under which the boiler is being built. Brass bushings would not be expected to leak when the boiler is under steam, since the coefficient of expansion of brass is greater than that of steel. Consequently the tendency would be for the joint to be tighter, rather than looser, with an increase of temperature.

Q.—Is cast-steel pipe reliable for a blow-off nipple?

A.—Cast steel pipe of the following physical qualities is suitable for blow-off nipples: tensile strength 50,000 to 65,000 pounds per square inch; elastic limit, minimum not less than 45 percent of the tensile strength; elongation in 2 inches, minimum 25 percent. Cast steel should, however, be well protected from direct action of the fire.

Q.—In looking over the specifications furnished by several leading manufacturers of boilers I find that it is customary to brace the area below the tubes in the head of a horizontal tubular boiler by the use of through rods, with additional diagonal braces provided for the back head where there is a manhole in the lower part of the front head. Apparently the flanged manhole in the front head is supposed to act as a stiffener for that part of the head, but I cannot see how the area of which the manhole is a part should not require the same support as the corresponding area in the back head, assuming that the combined braces in the back head are only of sufficient strength to safely carry the intended load? MISSOURI.

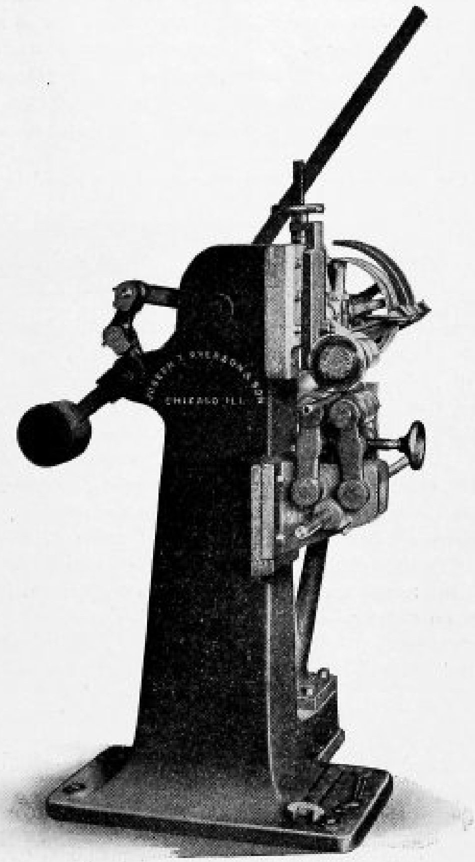
A.—Provision should be made in such boilers for bracing the part of the front head occupied by the manhole by means of diagonal braces at the sides of the manhole. The flange of the manhole will, of course, act as a stiffener and will help to brace the head, but it must be supported in some way. If braces are not placed there for this purpose, the additional stress goes on the neighboring through braces and the flange of the head, and, while the factor of safety of these parts is probably sufficient to carry the load, yet it should not be depended upon for this purpose.

ENGINEERING SPECIALTIES.

Ryerson Flue-Cutting Machine.

There has long been a call for a good substantial machine, for cutting pipe or tubes, of sufficient capacity to handle the general range of work, designed in such a way so as to occupy a small amount of floor space and simple enough in its operation to permit of its being run by unskilled help.

After years of experimenting along this line, Joseph T. Ryerson & Son, Chicago, Ill., have placed on the market the machine herewith illustrated. This machine is claimed to be practically noiseless in operation, and has a capacity for cutting



tubes or pipes from ⅜ inch to 6 inches diameter. It is arranged so that the work may be cut off any desired length, and is said to be very rapid in its operation.

The cutter wheel is direct connected by means of a knuckle-joint shaft to a 12-inch by 3-inch pulley, which should travel about 200 revolutions per minute. The object of the knuckle-joint drive is to permit the tubes or pipes to be run out back of the machine, so that they may be cut to any desired length. The feed of the cutter is accomplished by means of the hand lever shown; a balance weight being provided to secure an automatic release. The lever is so balanced that it requires but very little pull upon it to cut tubes of any size. The rollers on which the tubes revolve are arranged so they can be brought close together or spread apart quickly to the proper distance for taking care of the various sizes of tubes or pipe.

For reaming out the slight burr from the inside of the tube, which is sometimes caused by the cutting wheel, a fluted reamer is provided, and attached to the end of the shaft as shown. This reamer will ream tubes up to and including 3 inches in diameter. A larger reamer for tubes of greater diameter can be furnished and attached to the opposite end of the shaft just outside of the end bearing box.

Each machine is furnished complete with one cutter wheel, 4½ inches diameter, and a fluted reamer for handling tubes up to 3 inches in diameter, and all the necessary wrenches. The total weight is approximately 825 pounds.

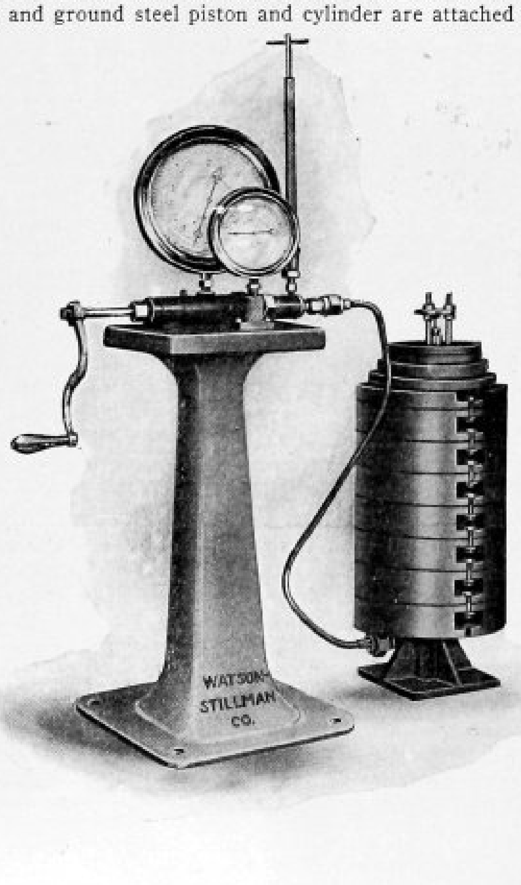
Improved Calibrating Apparatus for Hydraulic and Other High-Pressure Gages.

The bursting of machine parts and fittings from excessive fluid pressure is usually accompanied by considerable danger, expense and delays for repairs. For this reason pressure gages should be calibrated at regular intervals. Under the higher hydraulic pressures it is frequently the case that the same gage will show different percentages of error at different pressure readings, and these can be compensated for in ascertaining the true pressure only by comparing with a "master" gage of known accuracy or by loading with a known pressure.

The outfit which we illustrate performs these two functions of testing by comparison with a master gage and of testing the accuracy of the master.

For the first only the part on top of the stand is required. This consists primarily of a cross made of hydraulic bronze. The gage being tested, which may register any pressures up to 16,000 pounds per square inch, and the master are attached to the front and back ends of the cross respectively. At the left is a crank-operated screw displacement piston, by means of which the desired pressure may be produced within the pressure chamber. A suitable stuffing-box prevents leakage past the piston. To the right end is connected a stop valve and filling cylinder. This permits (1) some of the liquid to be withdrawn from the pressure chamber before removing the gage being tested and (2) filling after a gage is put on. There is thus no danger of spilling the oil.

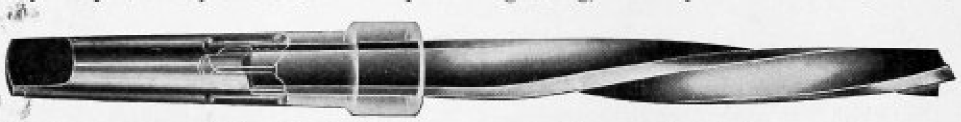
For testing the master gage, the special weight-loaded, hardened and ground steel piston and cylinder are attached at the right by means of flexible copper tubing, as shown. These parts are cut out by a stop valve when not testing the master. The cylinder is long enough to have the center of gravity of the weight below the center of support. When the weights are revolved the friction due to lifting the weights is practically eliminated.



The aparatus is made by the Watson-Stillman Company, of New York.

Celfor Reamers.

The Celfor reamer, manufactured by the Celfor Tool Company, Buchanan, Mich., is made from a specially rolled section of high-speed steel. It is twisted while hot with a left-hand twist, and is ground to a taper for 3 inches back from the point. Clearance is provided on each of the three flutes throughout the length of the reamer, clear up to the cutting edge. The left-hand twist gives a spiral cutting edge, which allows a shearing cut to be taken. As a result, it is claimed that the reamer lasts an exceptionally long time without regrinding, and requires much less power per cubic inch of material removed. Furthermore, the reamer does not tend to "draw itself into" the hole being reamed.



It should be noted that the Celfor reamers are accurately ground to a true diameter. They are designed to be held in sockets of very strong and simple construction. These sockets ordinarily are provided with Morse taper shanks of large size. For reaming to proper diameter punched holes in plate work the Celfor is claimed to be excellent. It is extremely tough and durable, and the section is so designed that it has great lateral strength in every direction. These qualities give it great value in reaming structural shapes and plates where the matching of superimposed punched holes is necessary. The sockets can be provided with special shanks where necessary.

Little Giant Splitting Shear and Scroll Punch.

The tool illustrated in Fig. 1 is a small splitting shear manufactured by the Little Giant Punch & Shear Company, Sparta, Ill. The shear plunger is actuated by a pintle, or link movement, with large bearing surface accurately planed and fitted. This wide bearing, it is claimed, assures perfect alignment of the shear blades at all times, making it impossible for the

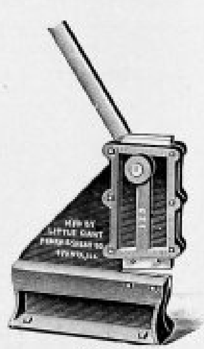


FIG. 1.

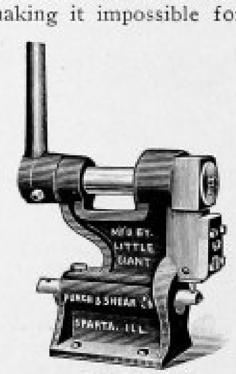


FIG. 2.

shears to spread while cutting. The lever works from either front or rear, and the body is made with sufficient clearance, so that the sheets will pass without binding. The shear blades are 4½ inches long and will split sheets up to ⅛ inch thick, or cut bar iron 3/16 by 3 inches. The machine is 16½ inches high, weighs 90 pounds, and occupies a space 7 by 16 inches.

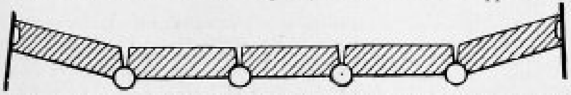
Fig. 2 shows a scroll punch manufactured by the same company, in which the die or die mandrel is small in diameter, in order to permit circular shapes or tubes being placed over it. Thus it is possible to punch gas pipe 1½ inches in diameter and larger. This tool is also convenient for cornice work, as it will punch flat sheets, or work formed in irregular shapes. The die mandrel is made of one piece of steel, with a die in each end, so that by turning the mandrel end for end a different size die can be used. The punch is actuated by an eccentric and sliding box, and a suitable steel stripper is furnished with each machine. This machine will punch a ¼ inch hole in 3/16 iron ⅞ inch from the edge. The sizes of punches with each machine are 3/16 and ¼ inch. The machine is 13½ inches high, weighs 75 pounds, and occupies a space 6½ by 14 inches.

SELECTED BOILER PATENTS.

Compiled by
DELBERT H. DECKER, ESQ., Patent Attorney,
LOAN AND TRUST BUILDING,
Washington, D. C.

934,723. LOCOMOTIVE BAFFLE-WALL. WILLIAM J. GRAHAM, OF CLEVELAND, OHIO, AND JOHN GERMAN, OF ELKHART, IND.

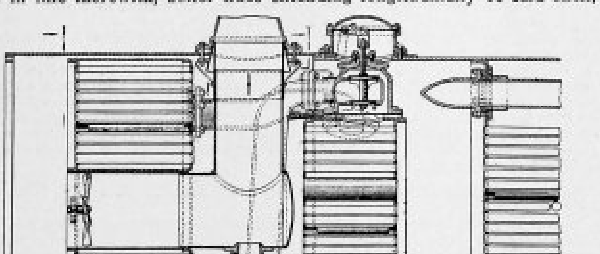
Claim 2.—A locomotive fire-box comprising in combination, side plates, longitudinally extending forwardly and downwardly inclined circulation tubes between the side plate, rows of bricks supported upon



the tubes, and a row of bricks extending from each of the outside tubes to the adjacent side plate, such bricks being socketed at their lower inside edges to engage the tubes at their upper and outer side portions and being upwardly inclined from their inner to their outer sides with their outer edges resting against the side plates. Four claims.

934,729. SUPERHEATER. HENRY W. JACOBS, OF TOPEKA, KAN.

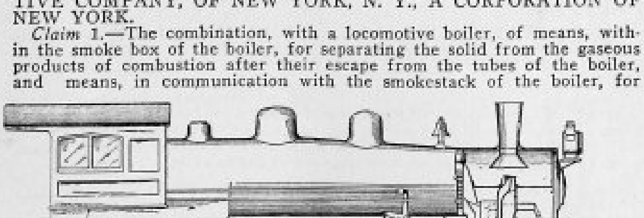
Claim 1.—In a locomotive, the combination of a boiler shell, a smokebox in line therewith, boiler flues extending longitudinally of said shell,



and a superheater mounted in said smoke-box, and sufficiently removed from said boiler flues to permit access between the superheater and flues for repairs, said superheater having a passage formed therein parallel to said boiler flues, through which boiler flues may be passed for repairs. Six claims.

934,767. SPARK-ARRESTING APPLIANCE FOR LIGNITE-BURNING LOCOMOTIVES. WILLIAM P. STEELE, OF PALISADE, N. J., AND JOHN PLAYER AND CARL J. MELLIN, OF SCHENECTADY, N. Y., ASSIGNORS TO AMERICAN LOCOMOTIVE COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

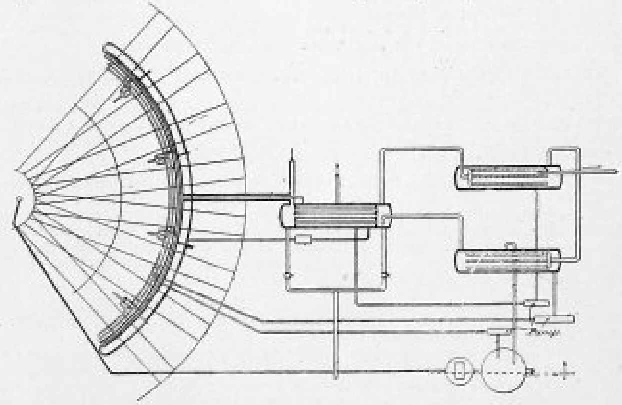
Claim 1.—The combination, with a locomotive boiler, of means, within the smoke box of the boiler, for separating the solid from the gaseous products of combustion after their escape from the tubes of the boiler, and means, in communication with the smokestack of the boiler, for



effecting a prolonged traverse, exterior to the smoke box, of the separated solid products, and thereby cooling them prior to their subsequent ejection from the stack by the action of the exhaust steam jet. Seventeen claims.

934,742. LOCOMOTIVE WASHOUT AND REFILLING SYSTEM. FRANK W. MILLER, OF CHICAGO, ILL.

Claim 1.—In an apparatus for discharging, cleaning and refilling boilers, the combination with means for separating the discharged steam



from the discharged liquid, of means for utilizing the discharged liquid as washout water, means for passing the discharged steam through fresh feed water, and means for mingling the steam rising uncondensed from the feed water with the washout water. Three claims.

937,898. STEAM-BOILER FURNACE. FRANK WAGNER, OF NEWPORT, KY., ASSIGNOR OF ONE-THIRD TO JOSEPH M. BETZ AND ONE-THIRD TO FRANK F. HAMMER, OF NEWPORT, KY.

Claim.—In a steam boiler furnace adapted to use gas as fuel, having fire-brick floor and walls and divided by vertical walls making a series of combustion or fire chambers, each chamber having a vertical column placed behind an air opening in the floor, said vertical columns dividing the combustion particles in such a manner as to cause them to spread throughout the fire chamber, and a brick wall built with suitable openings for equalizing and retaining heat, and placed behind said fire chambers. One claim.

937,782. WATER-TUBE BOILER. HAROLD F. ELY, OF BROOKLYN, N. Y.

Claim.—A water-tube boiler comprising a casing having a grate at the lower front portion thereof, and front and rear bridge walls forming a pocket or chamber in rear of the grate, a drum at the upper front portion of the casing, drums at the upper and lower rear portions of the casing, the lower rear drum being arranged between the rear wall of the casing and rear bridge wall, upper and lower inclined sets of water tubes connecting the front drum with the rear drums, a vertical set of water tubes connecting the rear drums, inclined partitions above and below the lower set of inclined tubes and extending respectively from the lower rear drum to a point in advance of the front bridge wall and from the front drum to a point in rear of the front bridge wall, said partitions being thus arranged to provide passages above said pocket and in communication with the upper front portion of the furnace chamber for the circulation of the flames and products of combustion from the grate over the front bridge wall, into said pocket, and upwardly and forwardly between the lower set of tubes and partitions to the upper portion of the chamber, whereby the upper set of tubes between the front drum and upper rear drum will be heated, and a vertical transverse partition depending from the base of the upper rear drum between the adjacent ends of the banks of tubes connected therewith and terminating above the rear ends of the upper partition and lower inclined bank of tubes and forming with the rear wall of the casing a vertical flue or passage inclosing the vertical tubes and the lower rear drum and having an outlet at its upper end and an inlet between the lower end of said vertical partition and the rear end of said upper inclined partition. One claim.

937,948. BOILER ALARM. FRED CAMPBELL McADAM, OF LOS ANGELES, CAL.

Claim 1.—In a boiler alarm, a fluid-controlling valve, a valve operating spring, a spring holding bar, a spring clamping plate arranged on one end of said bar, a clamping nut and collar having a threaded engagement with said bar, whereby said plate is held in clamped engagement with said spring and the latter held in retracted or inoperative position, a lever connected at one end to said collar and at its opposite end to said valve, and a fusible material adapted to secure said spring holding bar in position to retain said spring in a retracted position. Three claims.

938,022. STEAM-BOILER FURNACE. FRANK A. SHOEMAKER, OF BUFFALO, N. Y., ASSIGNOR TO JAMES STURDY, OF BUFFALO, N. Y., AND JOHN STURDY, OF CRAFTON, PA.

Claim 1.—A boiler furnace having a boiler, a combustion chamber, a rack of water tubes connected to the boiler, and a firing magazine separated by the rack from the combustion chamber, the passages through the rack between the water tubes being flaring and wider at the outlet end facing the combustion chamber than at the inlet end. Thirteen claims.

937,967. SHAKER FOR GRATES. WILLIAM J. SIMPSON, OF KOOTENAI, IDAHO, ASSIGNOR OF ONE-HALF TO LEWIS W. HAMEL, OF KOOTENAI, IDAHO.

Claim 1.—The combination with a locomotive axle and shaking grate of a support extending across under the axle, a slide mounted on the support and operatively connected to the grate, a movable carrier mounted on the support, a wheel on the carrier, and arranged to be moved into or out of contact with the axle, a pitman connecting the wheel and the slide, and means to shift the carrier. Two claims.

938,035. HORIZONTAL BOILER. EMIL A. BEYL, OF MINNEAPOLIS, MINN.
Claim.—In a horizontal boiler, the combination with a main cylindrical shell segmentally cut away on its under side and provided with segmental crown sheet 8 and segmental flue shee 9 co-operating with each other and said shell to afford the upper end of the fire box, of the pair of concentric vertical cylinders 10 and 11 spaced apart and connected water tight at their lower ends, and which cylinders 10 and 11 have, on their upper ends, segmental joint flanges both riveted fast to said main shell of the boiler with the intervening portion of the main shell perforated to connect the water spaces of the main shell and the leg formed by the parts 10 and 11, a grate at the bottom of the cylinder 10, and a fuel admission door at the top of the fire box. One claim.

938,134. FEED-WATER HEATER. HARRY ETHERIDGE, OF ZELIENOPLE, PA.
Claim 3.—The combination with a feed-water heater, of an outlet member located at the water line thereof, a valve seated on said member adapted to be operated by the exhaust pulsations, and means to limit the movement of said valve. Four claims.

938,036. FIRE-BOX. WILLIAM D. BOYCE, OF ST. LOUIS, MO.
Claim 2.—A fire-box having a side wall provided at the front end with openings discharging vertical sheets of air across the path of travel of the combustion products, and nozzles at the front corners of the fire-box for projecting horizontal sheets of steam across the air sheets and in a direction opposed to the general direction of flow of the combustion products. Four claims.

938,171. LOCOMOTIVE BOILER. SIDNEY A. REEVE, OF WORCESTER, MASS., ASSIGNOR TO CHARLES F. BROWN, TRUSTEE, OF READING, MASS.
Claim 1.—A locomotive-type boiler having water-vaporizing, steam-superheating and water preheating surfaces, heating flues adapted to conduct the gases over said surfaces successively in the order named and in forward and return directions, a stack at the rear part of the boiler adapted to discharge a portion of said gases before they have completed the entire passage of said heating surfaces, and a second stack at the forward part of the boiler adapted to discharge gases which have completed the entire passage. Seven claims.

938,449. SUPERHEATER BOILER. EDWARD H. WELLS, OF MONTCLAIR, N. J., ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.
Claim 1.—A superheater comprising a plurality of similar U-tubes each having its legs in a substantially vertical plane, corresponding legs of all of said U-tubes lying in an inclined plane, in combination with suitable inlet and outlet connections for the ends of said tubes. Two claims.

938,495. AIR-FLUE BLOWER. LOUIS LUNSTRUM, OF COUNCIL BLUFFS, IA.
Claim 2.—In an air flue blower, a hollow head tapered to fit a boiler tube, a pipe sliding longitudinally through said head and a flexible tubing connecting with said head adapted to receive and discharge material forced into said head. Seven claims.

938,568. STEAM SUPERHEATER. ERNEST H. FOSTER AND JOHN PRIMROSE, OF NEW YORK, N. Y.
Claim 2.—The combination with a steam boiler, having a fire box or furnace, and a smoke box, of two pairs of companion headers extending lengthwise of the smoke box, one member of each pair being located in an upper part of the box near the center thereof and the other member of each pair being located near the bottom of the box, superheating tubes connecting the upper and lower headers respectively, inclosing chambers for the superheaters, means within the chambers for causing the circuitous passage of hot gases therethrough, and means for discharging gases from the upper row of fire tubes into the rear portion of the chambers, the front portion of said chambers being in communication with the smoke outlet. Two claims.

938,573. FEED-WATER HEATER. GEORGE H. GIBSON, OF MONTCLAIR, N. J., ASSIGNOR TO JOSEPH S. LOVERING WHARTON, WILLIAM S. HALLOWELL, AND JOHN C. JONES, OF PHILADELPHIA, PA., A FIRM.
Claim 2.—In a feed-water headter, the combination with a heater tank and the usual steam supply and hot water discharge connections thereto, of means directly responsive to the steam pressure in the tank for admitting water to the heater when said pressure exceeds a predetermined amount, a storage reservoir, and connections between the heater tank and reservoir to permit water to overflow from said heater into the reservoir. Eight claims.

938,593. WATER-TIGHT HATCH OR MANHOLE COVER. MAXIME ALFRED LAUBEUF, OF PARIS, FRANCE.
Claim 2.—A hatch closure comprising in combination with the walls of the hatchway, an arm pivoted to said walls; a hatch cover pivoted to said arm and adapted to close said hatchway; a hook carried on said arm; a sliding member; a second hook pivoted to said sliding member; mechanism for moving said sliding member; and means adapted to move said second hook into and out of engagement with said first hook as the sliding member is moved.

939,031. WATER-TUBE BOILER. GEORGE KINGSLEY, OF NEW YORK, N. Y.
Claim 1.—In a water-tube boiler, a water-wall comprising an inner and an outer plate spaced apart and marginally secured together and provided with stay-bolts, one of said plates being shaped with projecting swells to form an upper steam drum and a lower mud drum, and a series of inwardly-extending tubes secured to said inner plate and communicating with the water-wall and having their inner ends closed. Nine claims.

939,010. FEED-WATER PURIFIER. THOMAS GRIEVE, OF PERTH AMBOY, N. J.
Claim 1.—A feed-water purifier or cleaner comprising a horizontal receptacle having an imperforate bottom and sides and a feed-water inlet at one end and an outlet at its other end, a series of separated deflecting plates shorter than the width of the receptacle and secured within the same and inclined toward the outlet, and a second series of deflecting plates interposed between the first series of plates and inclined toward the inlet, said two series of plates forming a continuous and sinuous passage in said receptacle, a blow-off pipe having a series of openings and parallel and adjacent each side, whereby the feed-water is compelled to flow alternately forward and backward across the bottom and toward the blow-pipe openings. Five claims.

936,498. TURBINE FOR DRIVING BOILER-TUBE CLEANERS. HENRY F. WEINLAND, HERMON G. WEINLAND, AND GEORGE H. AINGE, OF SPRINGFIELD, OHIO, ASSIGNORS TO THE LAGONDA ANUFACTURING COMPANY, OF SPRINGFIELD, OHIO, A CORPORATION OF OHIO.
Claim 1.—In a lubricating device for turbine such as described, a feed head having a chamber formed therein with ports to the runner of the turbine, a bearing for the rotating shaft of the turbine also formed in said head and a nozzle screw threaded into a recess in said head forming an inlet of gradually-increasing diameter to admit the actuating medium to said bearing from said chamber. Seven claims.

936,607. LOCOMOTIVE BOILER. GEORGE COOK, OF ELBA, N. Y.
Claim 2.—In combination, a boiler shell, a steam drum, a tube casing in the shell, water tubes in the casing opening opposite the steam drum, and a baffle plate in front of the discharge end of said tubes and between said discharge ends and the steam drum. Three claims.

936,651. BOILER FURNACE. EDWIN H. MONTGOMERY, OF DULUTH, MINN.
Claim 2.—In a steam boiler furnace, the combination of a fire-box, a bridge-wall, and a plurality of parallel heat absorbing and retaining walls in the rear of said bridge-wall and spaced therefrom, said parallel walls being spaced from one another and from the sides of the furnace, forming unobstructed longitudinal passages for the products of combustion, and each provided with a plurality of transverse openings. Three claims.

936,723. WATER-TUBE BOILER. RICHARD HUTCHISON, OF BROOKLINE, MASS.
Claim 3.—A water-tube boiler having oppositely disposed grates; a heat chamber provided with a flue at the top bridge walls and arches located in the lower part of said heat chamber; stoking doors for said grates at opposite sides of said heat chamber; water-containing units consisting of drums connected together by tubes, said units being located between said bridge walls and the walls of the heat chamber; other similar water containing units located over the arches; and baffle walls between adjacent water-containing units. Four claims.

935,651. FEED-WATER REGULATOR. JAMES W. GIVEN, OF SUTTON, AND JOHN L. FOGG, OF BEALLS MILLS, W. VA.; SAID FOGG, ASSIGNOR TO SAID GIVEN.
Claim 1.—The combination with a steam boiler, of a tubular thermostat located exteriorly thereof, but connected at its lower end to said boiler at the low-water level thereof, a feed pipe entering the boiler, a valve therein, a waste pipe leading from the feed pipe, a valve therein, a lever connected at one end to the feed pipe valve and at its other end connected to the waste pipe valve, and a rod connected to one end of the lever and at its other end to the thermostat, whereby when the thermostat expands the feed-water valve shall be opened and the waste valve closed, and when the thermostat contracts the feed-water valve shall be closed and the waste valve opened. Two claims.

935,141. BOILER-FLUE CLEANER. WILLIAM B. CLOWERS, OF LEHIGH, OKLAHOMA.
Claim.—The combination with a furnace and a flue boiler, there being a smoke box extending back of the boiler and a compartment in rear of the smoke box and out of communication therewith, of a distributing head fixedly mounted within said compartment, valve means for directing steam into the head, parallel guide tubes extending from the head and toward the smoke box, there being apertures in one wall of the smoke box and registering with the tubes, a member slidably mounted on the guide tubes, parallel nozzles fixedly connected to said member and slidably mounted on the tubes and within the openings, means for shifting said member to simultaneously move the nozzles through the apertures toward the tubes of the boiler, or into the compartment and close to the head, and packing interposed between each nozzle and its guide tube. One claim.

935,202. OIL-BURNING FURNACE. CHARLES A. HAMMEL, OF LOS ANGELES, CAL.
Claim 1.—An oil-burning furnace, the entire bottom of which inclines rearwardly whereby to deflect the heat away from the front of the furnace, and a burner located in proximity to the rear end of said bottom and discharging into the combustion chamber over the bottom. Twelve claims.

935,223. SUPERHEATER FOR LOCOMOTIVES. ORAN W. OTT, OF OAK PARK, ILL.
Claim 1.—In an apparatus of the class described, a boiler comprising flues, a drum within the shell between the flue sheets inclosing a plurality of said flues throughout their length, an open-ended shell inclosing part of the flues in said drum, said shell having its ends within the ends of the drum and having an annular connection at one end with the drum, and a steam inlet to the drum one one side of said connection and a steam outlet from the drum on the other side thereof. Five claims.

935,224. SUPERHEATER FOR LOCOMOTIVE BOILERS. ORAN W. OTT, OF OAK PARK, ILL.
Claim 1.—In an apparatus of the class described, a boiler, flues, a superheater drum inclosing a plurality of said flues from their forward ends to a point adjacent their rear ends, the forward end of said drum abutting against and being attached to the inner face of the front flue sheet, a shell inside of said superheater and inclosing part of the flues therein, and an annular partition joining one end of said shell to the side wall of the drum at a point intermediate the ends of the latter. Four claims.

935,884. WATER-TUBE BOILER. JOHN E. BELL, OF BARBERTON, OHIO, ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.
Claim 1.—A water-tube boiler having at least two transverse steam and water drums connected by banks of tubes to a lower transverse mud drum or drums, a baffle between the two banks of tubes, a baffle in the rear of the second bank, and tubes adjacent to the rear baffle and connected to the circulation at their upper and lower ends. Ten claims.

936,412. STEAM-BOILER SUPERHEATER. FRANCIS J. COLE, OF SCHENECTADY, N. Y.
Claim 1.—In a steam boiler superheater, the combination of a superheater casing extending longitudinally adjacent to a steam boiler and communicating, at its opposite ends, with the firebox and the smoke box thereof, respectively, a steam header supported in the smoke box, and superheater pipes located in the superheater casing and connected at their forward ends to the steam header. Eighteen claims.