INDEX TO

The Boiler Maker

VOLUME VII.

JANUARY TO DECEMBER, 1907

THE BOILER MAKER,
INCORPORATED,
17 BATTERY PLACE, NEW YORK, U. S. A.

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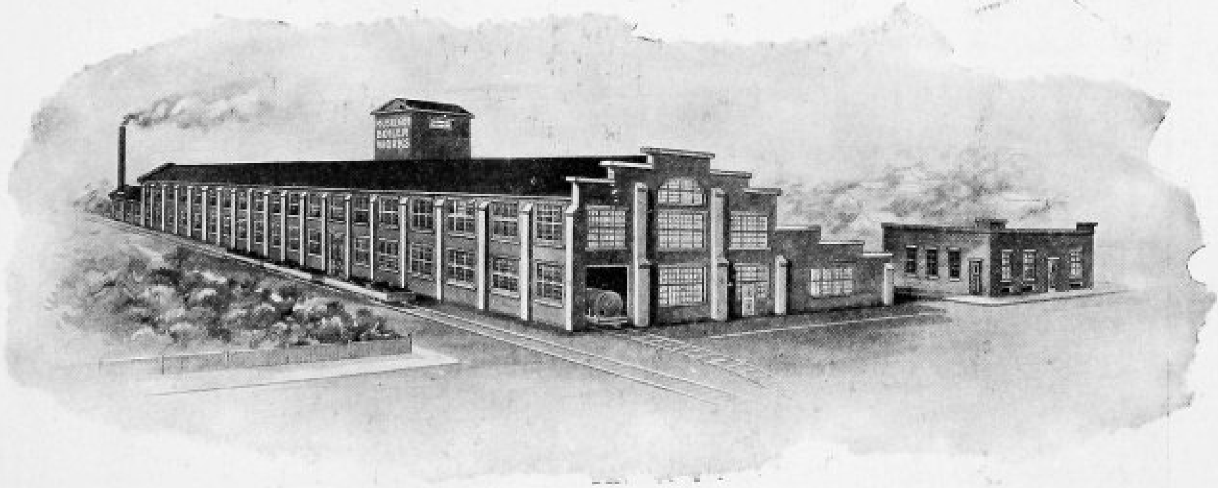
THE BOILER MAKER

VOL. VII **JANUARY, 1907** **No. 1**

MUSKEGON BOILER WORKS.

The Muskegon boiler shops are situated at 14-22 Eighth street, Muskegon, Mich. The main shop is 80 feet by 200 feet, built with a false end at the west for a future addition of 100 feet. The shop is of brick and frame construction, having substantial brick walls and extra heavy wood trusses and roof to withstand the strain attendant upon the operation of the many overhead cranes. As the building is located on made ground, it was necessary at some places to go down 6 feet with the foundation, which is of concrete. The wooden floors consist of 3-inch Norway plank laid on 4 by 4 Norway stringers, spaced 20 inches between centers, which are thoroughly tarred and laid in a bed of cinders.



EXTERIOR OF MUSKEGON BOILER WORKS.

The shop is divided into a main erecting floor 50 feet by 200 feet, served by a 10-ton electric crane with a 3½-ton auxiliary hoist. The bay, which is 25 feet wide and adjacent to the main erecting floor, contains the machine floor, which is served by a number of overhead 3½-ton traveling cranes; blacksmith shop, served by two overhead hand traveling cranes, one 2 tons and one 3½ tons; hydraulic riveting tower; stock and tool room, and stock floor which is served with an overhead 3½-ton traveling crane. In addition to the overhead traveling cranes, there are two 3-ton jib cranes, which serve the bevel shears and the big punch. The arrangement of cranes is such that every square foot of the shop is served.

At the west end of the main floor is located a large concrete drain connected to the sewer, on which boilers are placed for testing. The superintendent's office is located on the north side of the main floor, which gives it a central location convenient to all parts of the shop. In the northeast corner is located a lavatory for the men. At the east end and adjacent to the main shop is the power plant, consisting of the boiler and engine rooms, each 30 feet by 30 feet, and coal bunkers. In one corner of the boiler room is located a large wash basin where an abundance of hot water is provided for the men at noon and night.

The shop is located on the Grand Trunk Railway, from which it is served by two sidings, one entering the west end of the main erecting floor about three car lengths, and the other extending along the north side of the shop to the power house, where coal is unloaded directly from the cars to the coal bunkers.

The plan, Fig. 3, will readily show the locations of the various machines and tools which are as follows:

No. 1. Direct-connected 40-KW. 250-volt Northern engine type generator, and 11 by 10 automatic Skinner engine.

No. 2. Electrical switch-board.

No. 3. Ingersoll-Sergeant duplex air compressor 10 by 10 by 16¼ by 10 by 10¼ by 10

No. 4. Ingersoll-Sergeant straight line air compressor 10 by 10 by 10.

No. 5. Two 60-inch by 16-foot horizontal tubular boilers.

No. 6. Thirty-inch feed-water heater.

No. 7. Knowles vacuum pump for heating system.

No. 8. No. 10 Rodgers pump

No. 9. Fifty-four-inch by seventy-foot self-supporting steel, brick-lined stack.

No. 10. Worthington duplex pump for hydarulic riveter.

No. 11. Accumulator for hydraulic riveter.

No. 12. Air tank.

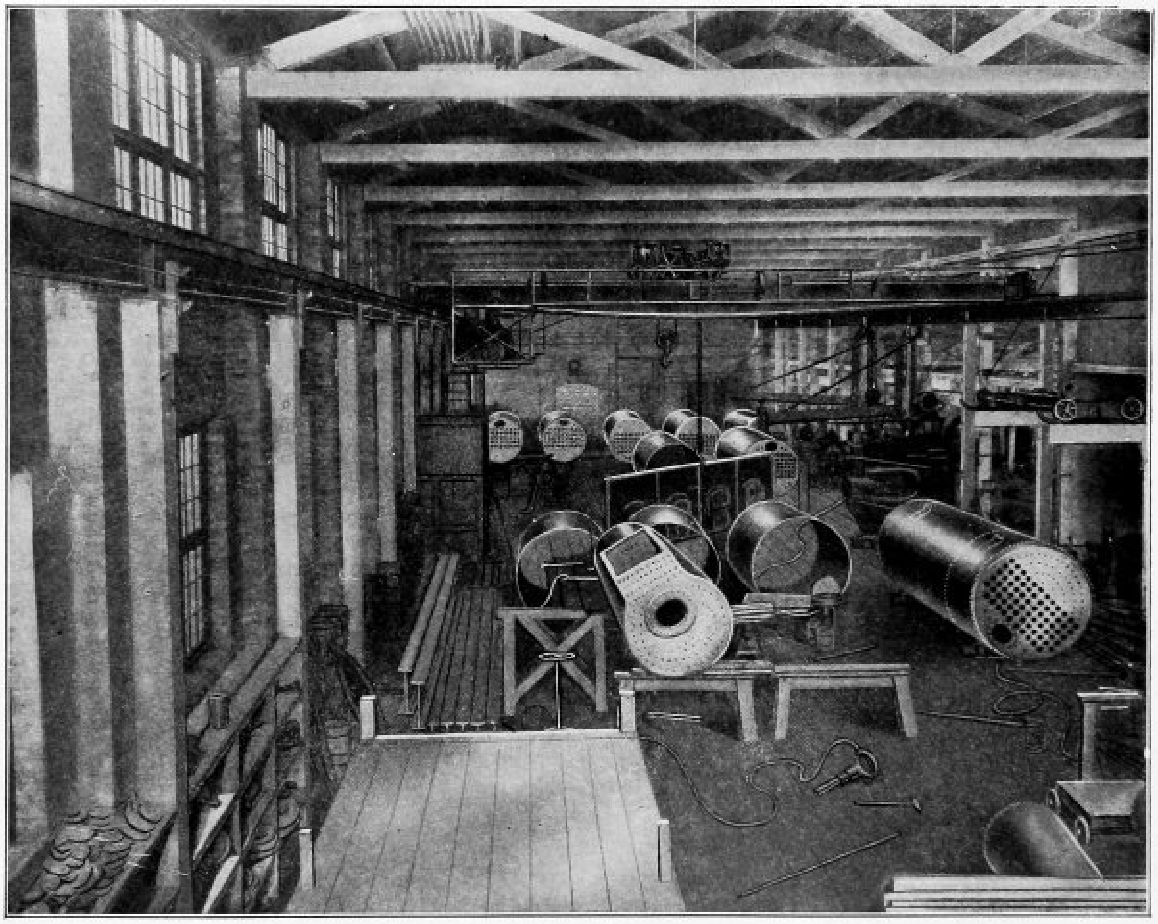
No. 13. Overhead flue-hole drill.

No 14. National No. 2 screw cutter.

No. 15. Twelve-foot Wall radial drill—motor driven.

No. 16. Long & Alstatter combined punch and bending machine—motor driven.

No. 17. No. 14 Emery grinder.
No. 18. Small punch.
No 19. Lennox rotary shear—motor driven.
No. 20. Hilles & Jones 48-inch punch—motor driven.
No. 21. Rodgers flue cutter.
No. 22. Rodgers 8-foot bending rolls.
No. 23. Niles 10-foot bending rolls—motor driven.
No. 24. McGrath pneumatic flue welder.
No. 25. Blacksmith fire.
No. 26. Flange fire.
No. 27. Fourteen-foot flanging clamps.
No. 28. Wood 9-foot hydraulic riveter.



INTERIOR VIEW OF MUSKEGON BOILER WORKS.

In arranging the tools, one line shaft extends along the south side of the machine floor back of the crane runway, under which all the belt-driven tools are placed. The other tools are motor or air driven, so that, in the arrangement of the tools, belting, countershafts, etc., are reduced to a minimum. The shop is thoroughly piped overhead for air, a line extending down each post for air-hose connection, so that but short runs of hose are necessary to reach any portion of the erecting floor.

A combination of incandescent and arc lights is used in lighting the plant, and the lights are so arranged that each tool receives good direct light from an arc lamp and also has an incandescent lamp which can be carried around dark sides of the work when working at the machines. Incandescent lamps are also provided with long cords to be used where work is being assembled. The plant is heated by the overhead vacuum system, the pipes being placed on the lower chord of the roof trusses. These pipes in the erecting floor are about 22 feet from the ground, but no difficulty is experienced in keeping an even temperature during the most severe weather.

The plans for the plant were prepared by the company's engineer, Mr. R. E. Ashley, who superintended the erection of the work. Prior to designing the building, he, with Mr. C. D. Stevens, general manager, visited several of the larger shops in Chicago, Milwaukee and vicinity, and, as a result, besides being the largest in Western Michigan, the shop is the most modern and conveniently arranged in this section of the country. The company is engaged in the manufacture of many different types of boilers, self-supporting steel stacks, refuse burners, breechings and heavy plate and sheet-iron work of every description. Their products are shipped to all parts of the United States.

Proportions of Scotch Boilers.

CARL H. CLARK, S. B.

The Scotch type of boiler having been so extensively used, certain proportions of the various parts have become recognized as giving satisfactory and economical working. These proportions are of great aid to designers in determining the proper size and design of a boiler for any given purpose.

LENGTH.

While the diameter of these boilers varies from 7 feet to 17 feet, according to the number and size of furnaces, the length varies only slightly, being governed by the length of furnace and depth of combustion chamber, which are only

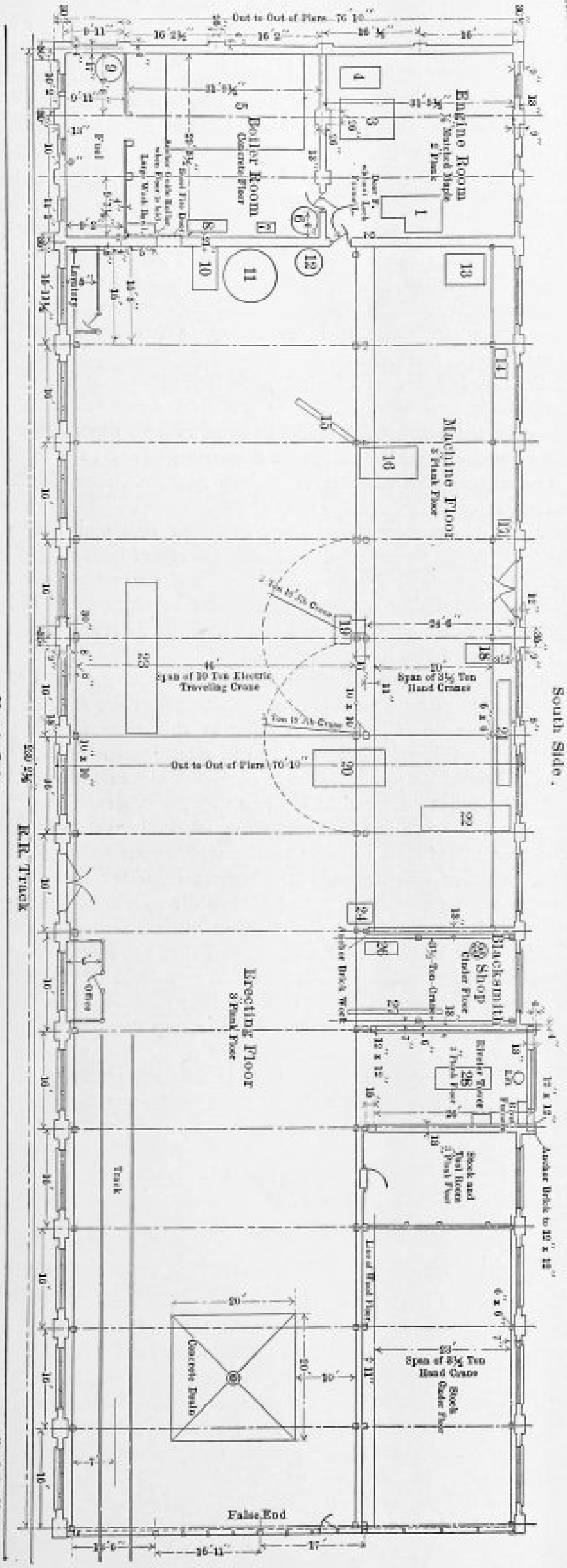


FIG. 3.—PLAN OF MUSKEGON BOILER WORKS.

slightly greater in the large boiler than in the small one. For single-ended boilers the length is from 10 feet to 12 feet. Double-ended boilers will be somewhat less than double the length of the single ended, or from 18 feet to 22 feet.

DIAMETER.

The diameter will run from 7 feet for a single furnace donkey boiler to 17 feet for a four-furnace boiler, depending largely upon the number of furnaces. While there are no distinct limits, the division may be stated about as follows: Single-furnace donkey boilers, 7 feet to 9 feet; two-furnace boilers, 10 feet to 12 feet; three-furnace boilers, 12 feet to 15 feet; four-furnace boilers, 15 feet to 17 feet.

FURNACES.

Furnaces vary in diameter from 30 inches to 54 inches, the most convenient diameters being from 38 inches to 45 inches. It is not, as a general rule, desirable to fit furnaces larger than 48 inches for other than moderate steam pressures. For the high pressures now in use the diameter would better be kept below 45 inches, as the large diameter demands an undue thickness of metal. It is not considered good practice at the present time to have a thickness of metal greater than 5/8 inch, as the thicker metal is liable to damage from overheating. On the other hand, a diameter of less than 40 inches necessitates a rather short grate, as, on account of the contracted space between grate and furnace crown, it is difficult to efficiently work the rear end of a long grate. Owing also to the limited volume of the furnace, the combustion is less complete on account of the small space for mixture with air. This condition may be bettered by sloping the grates downward toward the rear at the rate of about 3/4 inch to the foot. The length of furnaces is from 7½ feet to 9 feet.

GRATES.

With furnaces of ordinary diameters the grates vary in length from 5 feet to 6 feet, the larger furnace permitting the longer grate on account of the greater height. The intensity of the draft also influences the length of the grate, as under forced draft the extreme rear end of a long furnace does not receive the necessary attention, and a shorter grate is equally effective, while under easy natural draft conditions a long grate may be well taken care of. Grate bars should have air spaces of 1/4 inch to 1 inch, according to the size of coal used, with thickness of bars of 3/8 inch to 5/8 inch. The grate surface and heating surface should be so proportioned that the heating surface is from 29 to 32 times the grate area for natural draft. Any great variation of either from these proportions is a detriment rather than an advantage. Under forced draft the grate surface is naturally more effective, so that this proportion of heating to grate surface may run as high as 35.

COMBUSTION CHAMBER.

The depth of the combustion chambers is from 2 feet to 2½ feet, this depth usually giving a sufficient volume to promote combustion without cooling the gases unduly. Combustion chambers may be arranged in a variety of ways, as in a single-end boiler there may be either a single chamber common to all furnaces, or a separate one for each furnace. The single chamber aids combustion, as the gases from a fresh fire mix with those of the other fires and are more fully consumed. There is, however, a disadvantage to this arrangement, as the opening of one furnace door reduces the draft and consequent steaming capacity of the other furnaces. Where forced draft and a high rate of combustion are used, the separate combustion chambers should be fitted. Four-furnace boilers sometimes have two combustion chambers, one for each pair of furnaces; this is a good arrangement, as each furnace receives the benefit of the hot gases from its neighbor. Double-end boilers may be fitted as already described, or the opposite furnaces may have a common chamber. When this is the case, care must be taken that the comparatively cold gases from one furnace cannot strike the opposite tube sheet.

WATER SPACES.

Water spaces around combustion chambers should not be less than 5 inches, and better, not less than 6 inches, and should, wherever possible, increase toward the top to 9 or 10 inches, to allow the ready separation of the steam from the water. Furnaces should be not closer to each other, or to the shell, than 6 inches.

TUBES.

The diameter of tubes is measured outside and runs from 2 inches to 2½ inches for forced draft, and from 2¾ inches to 3½ inches for natural draft. The length of tubes are of course the same as those of the furnaces, 7½ to 9 feet. Tubes are usually set in vertical rows. A space of not less than 1 inch should be left between tubes in small sizes, increasing to 1⅜ inches in large sizes. The vertical space between the tubes is customarily made slightly greater than the horizontal space, to allow freer circulation. Where separate combustion chambers are used, a space of 10 inches or 12 inches may be allowed between adjoining banks of tubes, allowing access among them for examination and cleaning.

It is evident that, from an evaporative point of view, the small tube is more effective, as the radiating surface bears a greater proportion to the volume of gases passing through. The small tubes, however, have a tendency to choke down the draft and become clogged more quickly. For this reason small tubes can only be economically used with forced draft. The area through the tubes should be from 15 percent to 20 percent of the grate area.

STEAM SPACE.

It is necessary to have a certain amount of steam space to allow the separation of the steam from the entrained water, and prevent the latter from being carried over to the engine. A very good method is to allow about one-third the diameter above the top row of tubes, which will usually be sufficient.

FUNNEL.

The area of the stack is dependent upon its height and the intensity of the draft. For natural draft the area should be from 12 percent to 20 percent of the grate area, or about the same as the area through the tubes. It is of course desirable to make the stack as high as possible as an improvement in the draft results. Where forced draft is used a high stack is not as necessary, although even in this case it is desirable, as it aids in freeing the uptakes of the gases forced through by the pressure.

PERFORMANCE.

The size of boilers necessary for any installation may be figured from the desired I. H. P. on several different bases. The most common, and probably the most trustworthy basis, is that of the number of I. H. P. delivered per square foot of grate area. With triple engines the I. H. P. per square foot grate area will run from 7 to 12, with an average of about 10 for good ordinary conditions. With forced draft these figures will be from 12 to 20, with an average of about 15. On the basis of heating surface, one I. H. P. will require from 2½ to 4 square feet at natural draft, while for forced draft as low as 2 square feet may suffice. The amount of coal burned per square foot of grate area depends upon the intensity of the draft. Under natural draft conditions, from 15 to 20 pounds will be burned per square foot per hour, while under forced draft from 20 to 30 pounds will be burned. On the basis of I. H. P. with a triple engine 1.5 to 2.5 pounds per I. H. P. per hour should be allowed, according to conditions. The evaporation of water per pound of coal burned is usually from 6 to 10 pounds. The figures given above presume a fairly good quality of coal and efficient firing, otherwise the efficiency will be less. These figures, if used with good judgment, will give a boiler in accordance with the accepted practice of the present time.

Cause and Effect of Steam Boiler Explosions.

BY W. H. WAKEMAN.

Statistics show that for a certain given time there were fourteen persons killed and forty injured by steam plant accidents in Great Britain, and during the same time in the United States there were 383 killed and 585 injured. A contemporary points out the rather alarming fact that if we allow for 50 percent more boilers here than there, we kill and wound about ten times as many people as our much slower relations "on the other side" find it is necessary to disable, either permanently or temporarily.

As this is a matter of vital importance to steam users, and everybody that works, lives or travels near their plants, let us give the matter fair consideration in an honest effort to find out the cause for this most disastrous effect. The following incident which is an actual fact, will shed some light on the subject.

A certain party wanted the best boiler that could be procured. A very competent authority on steam boilers was engaged to carefully draw specifications and plans for the same, and several boiler makers were asked to state their lowest price for doing the work and supplying the material, the lowest bidder to receive the contract.

One bid was about $200 less than the next lowest, consequently the party who submitted it was given the contract.

We have no objections to offer at this time to the plan adopted in this case, but wish to call attention to the fact that if the lowest bid for a boiler is accepted, where the specifications have not been carefully drawn by an expert, it is a dangerous and unprofitable proceeding, as it always means that inferior materials and poor workmanship will be supplied.

The boiler was begun, but when an inspector was sent to watch the process he reported that while specifications stated that all holes should be drilled, they were punched in actual work. The boiler maker was notified that the boiler so made would not be accepted. As he could not bribe the inspector, he made a strenuous effort to show that such inspectors were theorists only, hence their decision in every day practice were of no value.

Finally, all argument in this case was peremptorily closed by the statement that the ability of the inspector had no bearing on the case, as the specifications must be complied with. This called forth an offer to sell the boiler for about $100 less than the contract price, but this was promptly refused, making it necessary to suspend operations on the boiler, procure new material and build another in which all holes were drilled.

In order that the matter may be clearly understood by the non-technical reader, we will state that when holes are punched in boiler plate the process disturbs the fiber of the iron or steel, which weakens it and in many cases starts cracks that lengthen as time elapses until they are decidedly dangerous. The drilling process is not open to this objection, therefore it makes a much stronger and more reliable job, but it is expensive, hence some boiler makers will not adopt it except in cases where they are obliged to.

What became of the rejected boiler? Was it cut up into scrap and sold for whatever it would bring? Oh, no. It was laid aside temporarily, to be finished later on and sold to another party who was not so particular. There is no reason to doubt that just as much pressure would be put upon it as if the holes were drilled, and as boilers are subjected to very high pressures at the present time, the difference in strength may make all the difference between safe operation and disastrous explosion.

This is only one case among many that might be cited in which poor management on one hand, and a mistaken policy on the other, unite to cause ruin and disaster, as the prospective purchaser fails to remember that as a rule to which there are very few exceptions, we get what we intelligently pay for, no more and no less, and the boiler maker who takes contracts at too low prices, expecting to make them pay by punching holes without carefully laying out the work, then using the drift pin to make them come "fair," doing poor work in riveting the joints, covering up defects in every possible way, by not putting in a sufficient number of braces, using poor material, etc., will find that he cannot secure desirable contracts because his reputation has preceded him.

Bearing in mind the fact that many of these inferior boilers are put into hard and continuous service, let us note the lack of precautions to secure really competent men for their operation.

In the first place, many of them are located in such unsuitable places that they cannot be properly cared for, and the compensation offered is so low that first-class men will not accept it for the simple reason that they either can find employment in more congenial quarters in the same line of work, or else are able to secure more pay at other work.

If we should explain things that are done by ignorant and incompetent boiler operators, and their effect upon the boilers, it would require many pages, yet these men are not always to blame for their action, as they are ignorant of the great force held in check by a steam boiler under high pressure, and know nothing of the principles involved in its safe operation.

The above-mentioned conditions are no longer surprising to anybody who has investigated the matter, but it is a never ceasing cause for surprise to find that wherever an attempt is made to improve these wretched conditions, it is met with strong opposition, which we regret to state is often strong enough to prevent the passage of wise laws that would benefit everybody concerned.

The national license committee of the N. A. S. E., report that license laws are in operation in the following States: Massachusetts, Minnesota, Montana, Ohio and Pennsylvania, also in Fulton County, Georgia, and in the District of Columbia.

These cities have procured the passage of ordinances requiring all operators of steam boilers under high pressure, to take out licenses stating that they are competent for such work: New Haven, Conn.; New York, Buffalo, Niagara Falls, and Rochester, N. Y.; Jersey City, N. J.; Philadelphia and Erie, Pa.; Baltimore, Md.; Detroit, Mich.; Goshen and Terre Haute, Ind.; Chicago and Peoria, Ill.; St. Louis, St. Joseph and Kansas City, Mo.; Sioux City, Ia.; Omaha and Lincoln, Neb.; Denver, Col.; Tacoma and Spokane, Wash.; Portland, Ore.; Los Angeles and Santa Barbara, Cal.

When discussing this subject, those who are not in favor of such legislation always ask if license laws wholly prevent boiler explosions, and to this we reply frankly, that they do not, but the number of these catastrophes is greatly reduced thereby in every city and State where the experiment has been tried, which should be convincing proof of its value to the community at large, and especially to steam users.

Furthermore, if the enactment and enforcement of such a law prevents the loss of one human life per year, it is sufficient to pay for the trouble and expense made necessary.

What is the actual cause of opposition to the enactment of conservative laws regulating the operation of steam boilers, by licensing those who are to operate and care for them? In a very large majority of cases it is due to the fact that owners of steam boilers wish to place the most available man in such a place, without special regard to his education and experience in this important business.

In every State where steam boilers are used, men can be found in charge of them who have never qualified for such work, except in States or cities where the law prevents such dangerous practice. Even those steam users who violently and systematically oppose such legislation claim that they always secure the best men to be found to run their boilers, but if this is strictly true beyond dispute, why should they care whether there is a law on the subject or not?

A competent steam engineer can convince any fair inspector that he understands the use and abuse of steam boilers, therefore he must be given a license for such work. If it is refused he can invoke the law and compel the inspector to issue the required document.

Why is it so much safer to live and work in the vicinity of steam boilers in Great Britain than in the United States? Simply because boilers are made under a far more thorough system there than here, which prevents the use of poor material and discounts dangerous methods of manufacture.

Another important reason is that men in charge of boilers carrying high pressures are much more thoroughly educated in their duties before they are allowed to endanger their own lives and the safety of others.

If competent engineers can prevent boiler explosions and other accidents, why do they not always do it, and thus wholly eliminate these catastrophes?

It is not possible to realize this most desirable condition of affairs, because hidden defects are responsible for some boiler explosions, and it is impossible to discover these until failure of the defective part and ruin of the whole, makes the cause known to the trained inspector, and it is then too late to prevent the disaster.

As an illustration of this, take the lap joint, or joint made by simply lapping one end of a plate over the other for 3 or 4 inches, and then putting in one or two rows of rivets to hold them together. When an engineer or an inspector goes into such a boiler, he can see the inner plate, but the outer is hidden from view and a brick wall covers it on the outside, consequently when a crack that was started when the boiler was made, or at some later period, begins to lengthen, it cannot be detected until too late to prevent trouble. On this account, and because this form of joint brings unnecessary strain on sheets, there is a decided tendency to abandon it by some boiler makers in favor of a more safe design.

There are thousands of vertical boilers in use that cannot be thoroughly inspected because no provision was made for entering them, consequently a boiler inspector can only apply the hydrostatic test, putting on 50 percent more pressure than such boilers are to carry in regular service. If any of them fail under this test, no further damage results, but if one or more parts are almost ruptured by the high pressure, there is no way of discovering the fact until the boiler explodes at some future time.

Further explantion of this test is in order at this time. It is a very simple process, as it consists of filling the boiler full of cold water, blocking or weighting the safety valve so that it will not open, then applying a pump to force in more cold water until the desired pressure is secured. If a tube collapses, or the shell is ruptured, surrounding property is not damaged because cold water is not expansive.

We are told on general principles that a little knowledge is dangerous, and the truth of this saying is sometimes illustrated by ignorant men in charge of boilers, who make tests without the use of a pump. The boiler is filled with cold water and a fire built under it. Heat causes the water to expand, raising the pressure as high as wanted.

This is a very dangerous proceeding, for if a rupture results, there may be heat enough in the water to cause an explosion of more or less violence, for it should be remembered when considering this matter, that the expansion of water is what causes disaster whenever a boiler explodes. The only safe plan is to use cold water only.

If an engineer fails to take all usual precautions to prevent trouble with his boilers, and somebody is killed as a natural consequence, his license may be revoked, if he is located where a license law is in effect, and this acts as a powerful incentive to gain knowledge on the subject, and to avoid accidents. It has been very interesting to the writer to note this, and observe the beneficial effects of it in practice, as it is an important move in the right direction.

Whenever it seems as if a license law might be passed in a State, county or city, the sale of mechanical books and papers is greatly increased, but if it is defeated normal conditions are soon restored, showing that where there is no special incentive, no special and systematic effort is made along this line.

With a progressive license law in force the incentive is always present, and the result is more satisfactory to all concerned.—*The Tradesman.*

Crude Oil Fuel.

Crude oil fuel is being used in the boiler plant of the Eagle Flour Mills at Newton, Mass., at a cost comparing very favorably with that of coal. About 170 barrels of oil are burned per week at a cost of from 3.99 to 4.69 cents per barrel of flour manufactured. The fuel cost when using coal averaged 4.6 cents per barrel of flour output, not taking account of the labor cost of handling the coal and stoking. The burner used is the Hammel crude oil burner, which uses steam for atomizing the liquid fuel, and no change was made in the furnace except to cover the grates tightly at the rear with bricks and sand, and at the front with half bricks laid loose with 1-inch air spaces; and to leave air openings on either side of the doors.

Triangulation

(Continued.)

A. H. S.

LAYING OUT A CIRCULAR HOOD FOR A SMOKESTACK.

In this article we will consider the development by triangulation of a circular hood for a stack which projects through an inclined roof. In Fig. 4 is shown the elevation of the stack; *ABCD* is the elevation of the circular hood. *A'B'* is the plan view of the stack and the circle *C'D'* the plan view of the outer edge of the flange. This shows as a circle in the plan view, as it is required that the flange be equal on all sides.

Fig. 6 shows an elevation *ABCD* of the hood similar to *ABCD*, Fig. 4. Above this elevation is a half plan of the top *AEB*. This half plan is divided into ten equal parts. From these points drop perpendiculars to *AB*. We must now obtain the actual shape of the section as it passes through the roof. To do this, construct the half plan of the base *GHK* and divide this semi-circle into the same number of equal parts as the semi-circle *AEB*. From these points erect perpendiculars cutting the line *GK*. Extend these lines to cut the line *CD*. From these points drop lines perpendicular to *CD*. On these lines lay out distances equal to the similarly numbered perpendicular lines on the half plan view *GHK*. Through these points draw a smooth curve. This gives us the true shape of the section as it passes through the roof and furnishes us with the stretchout of the base used in obtaining the pattern.

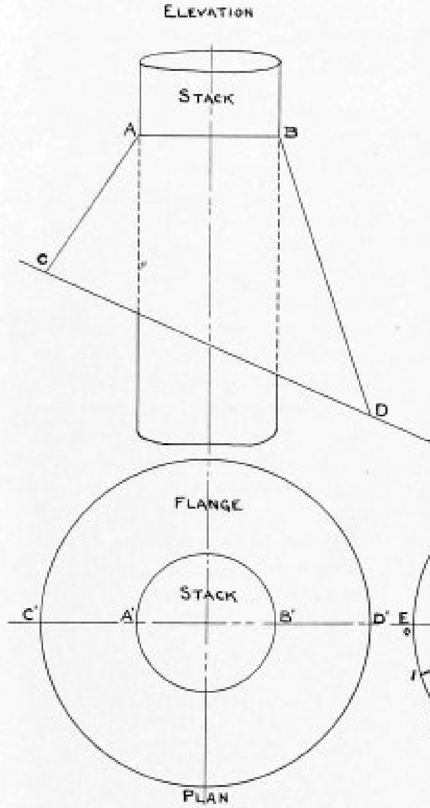


FIG. 4.

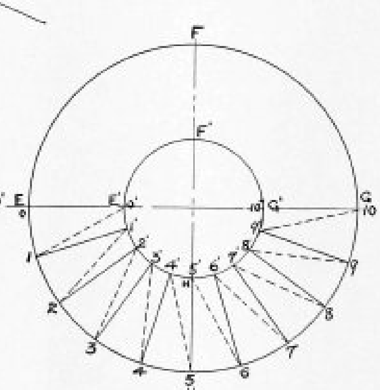


FIG. 5.

We are now ready to prepare for constructing the triangles for developing the pattern. In Fig. 5 construct a plan view of the hood similar to that shown in Fig. 4. Divide these semi-circles similarly to the semi-circles in Fig. 6 and number the points on the smaller semi-circle, *E'H'G'*, from 0' to 10' and the points on the larger semi-circle *EHG* from 0 to 10. Connect the points 0-0', 1-1', 2-2', 3-3', etc., with full lines, and the points 0'-1, 1'-2, 2'-3, 3'-4, etc., with dotted lines. These solid and dotted lines form the bases of a series of right-angled triangles, whose altitudes are obtained from the elevation, Fig. 6. The hypothenuse of these triangles will give us the correct lengths of the lines on the pattern.

Returning to Fig. 6, connect the points on *AB* with the correspondingly numbered points on the line *CD*. Also extend the lines *AB* and *DS* indefinitely to the right. Do the same with the points on the line *CD*. At *S* erect a perpendicular line between the lines *BR* and *DS*. At *S* set off the distance *SQ* equal to the distances 0'-1, 1'-2, 2'-3, etc., Fig. 5. At *Q* erect a perpendicular cutting the line *BR* at *P*. Join *P* with the points, 0, 1, 2, 3, etc., on the line *RS*. This gives us the true lengths of the dotted lines on the pattern. Now at *O* on line *DS* erect a perpendicular line cutting the line *BR* at *N*. Now set off the distance *OM* equal to the lengths of the full lines in Fig. 5, 0-0', 1-1', 2-2', etc., which are all equal. Erect the perpendicular *ML* and join *L* with the various points on the line *NO*. This gives us the lengths of the solid lines on the pattern.

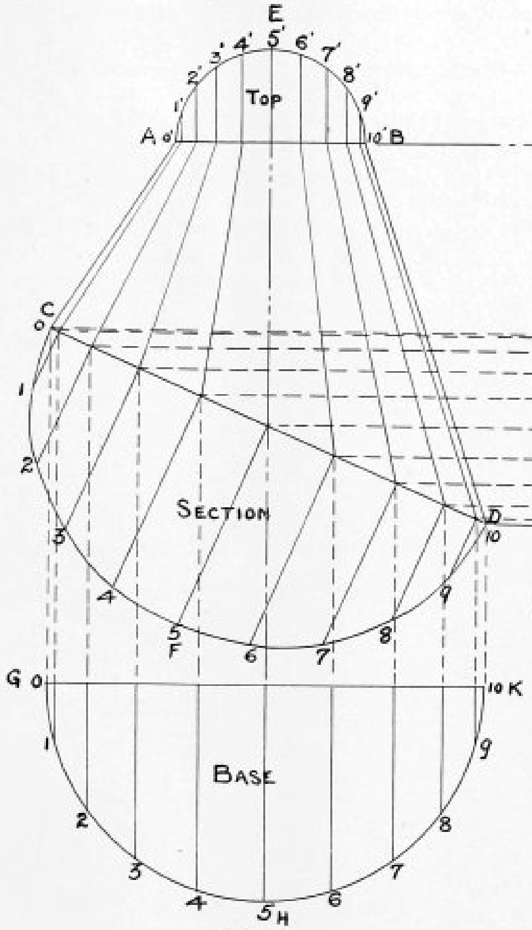


FIG. 6.

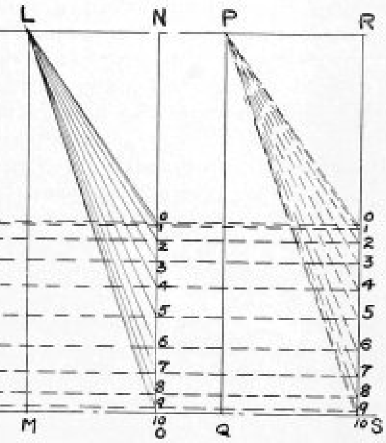


FIG. 7
DIAGRAM SOLID LINES

FIG. 8
DIAGRAM DOTTED LINES

We are now ready to lay out our pattern. The stretchout of top end of the flange is obtained from the semi-circle *AEB*, Fig. 6, and that of the lower part, or where the flange strikes the roof, is obtained from the section *CFD*, Fig. 6. Draw the line *A'C'*, Fig. 9, equal in length to *AC*, Fig. 6. Set a pair of dividers to the distance 0-1 on *CFD* and another pair to the distances 0'-1', 1'-2', etc., on *AED*. These distances are all equal. With 0 as a center and 0-1 on *CFD* as a radius strike the arc 0-1. With 0' as a center and the distance *P*-1, Fig. 8, as a radius, strike an arc cutting the previously constructed arc at 1. With 1 as a center and the distance *L*-1, Fig. 7, as a radius, strike an arc, and with 0' as a center and the distance 0'-1', Fig. 6, as a radius, strike an arc cutting this arc at 1'. Continue this process until the points 10 and 10' are reached. Draw a smooth curve through these points and join 10 and 10'. The resulting surface *A'B'C'D'* gives us the development of one half of the hood. The other half is exactly similar.

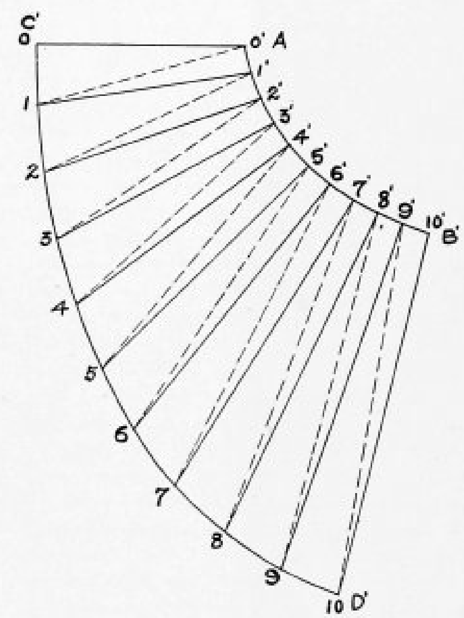


FIG. 9.

Bennington's Exploded Boiler an Object Lesson to Middies.

The boiler which exploded on board the Bennington in San Diego harbor last year, killing sixty-five of the ship's crew, is to be sent to Annapolis, where it will be used at the Naval Academy in the instruction of the midshipmen in engineering.

The object lesson will be a good one, because there is a tendency in engineering circles to slight practical instruction in regard to boilers. The engineering student at the end of his course is apt to find that he has a general idea of how to figure the horsepower, evaporation, etc., of a boiler, but that he knows little about the actual conditions of a boiler in service.

Causes of Cracked Flue Sheets.

One of the most frequent failures observed in a round top or radial-stayed fire-box is the cracking of the flue sheet at the knuckle of the flange or from the upper tube holes up to the rivet holes in the flange. Some discussion of the causes of such failures and the means of preventing them has recently appeared in the *Railway Journal*. Mr. W. H. Graves writes as follows:

The generally considered cause of this effect was first thought to be the method of working the flues, causing the upper holes to distort, creating stresses that in a short time caused the flue sheet to crack. When this theory failed to answer the question, the radial stays were assigned as the cause. It was then that sling-stays were advocated as a cure, but we were still confronted with the same old effect in the same old place, and a moment's reflection will show that when the sheet starts to expand the stays will have a bending movement introducing new stresses and these new stresses gives us no foundation to guard against this repeated distortion, resulting in a sheet failure.

The writer made a series of experiments several years ago on a road in New Mexico in a very bad water district, but as they did not extend over an extended period, I was only led to surmise that other causes were the direct means of inducing this failure, and going soon after to a road where the water was almost pure—and engine failures, due to leaky tubes or fire-boxes were unknown, and this failure of cracked flue sheet had never been observed, led me to believe that a further series of experiments along this line of reasoning covering a period long enough either to prove or disprove the theory, that I desire to place before those who may be in a position to demonstrate its truth or fallacy, the writer will feel amply repaid for what little trouble it has given him. As it is well known our fire-box temperature in our high-pressure engines is between 2,000 and 2,400 degrees. This intense heat impinging on the upper part of the flue sheet, has a tendency to overheat the plate and after the engine has been in service a short time the flue sheet has a layer of scale. The spacing of the flues is such that it impedes the free circulation of the water, the temperature of the flue sheet is increased and the water instead of carrying off the heat by connection, loses its identity and reflects the heat back to the sheet; the water assumes the spheroidal state, and as the temperature of the sheet is increased, the area where the water has assumed this condition is increased until it extends to the top of the flue sheet. The steam globules are vastly increased in size, resulting in the water over the knuckle assuming the spheroidal state, the sheet is subjected to a compression strain due to the pressure in the boiler, and as the boiler is cooled down the sheet has a tendency to revert to its original position, resulting in a compound stress; one due to compression and one to expansion and contraction, and these repeated soon cause the sheet to crack. The use of flexible stay-bolts I do not believe will cure this as their action is similar to sling-stays, although I would like to see them tried and the effect noted. When the theory first occurred to me, I used a shield made of fire-brick arches. These were held in position by four studs in the top of the flue sheet protecting the top row of flues and flange and during my period of observation covering eight months, we did not have a flue sheet crack in the top knuckle.

Notkine Locomotive Superheater.

In the mostly used round section of the Notkine superheater for use in locomotive and marine boilers (*B*, Fig. 1) the central molecules will have a less superheat comparatively than the molecules of steam close by the circumference of the section. The efficiency of superheat of a certain steam volume (steam jet) passing through a round section is, therefore, diminishing from the circumference to the center of the round section and can be expressed through the length of superheating circumference (or heat distributing circumference) for each square unit of the section, or:

$$k = \pi d \div \frac{\pi d^2}{4} = \frac{4}{d}$$

The larger the diameter d of the tube, the less the efficiency

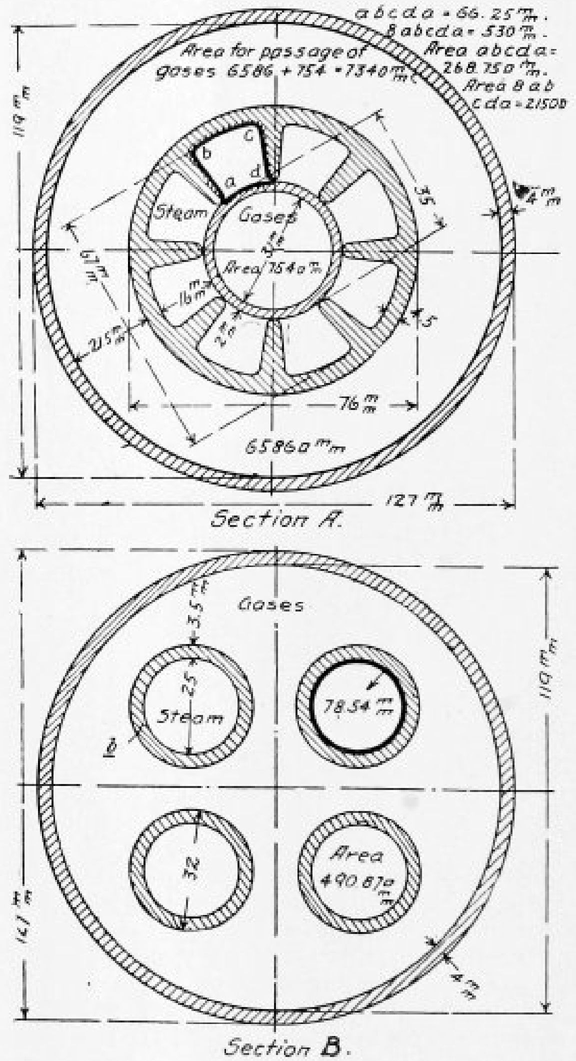


FIG. 1.

of superheat. For a tube $d = 25$ mm. or 1 inch, (Section *B*) $k = 0.16$.

An important improvement in the efficiency of superheat can be obtained by a form which leads the saturated steam through an annular space formed by the inner circumference of a ribbed tube and the outer circumference of a smooth tube put into the former so as to touch the ribs (Section *A*, Fig. 1). The annular space is divided by the ribs, forming an increased superheating surface and small compartments. The heated gases spread over the outer smooth surface of the ribbed tube and pass through the inner tube.

In a ribbed tube of 3 inches outside diameter, the inner heat-distributing surface will be 420 mm.; the same surface of the inner tube 110 mm.; the whole heat-distributing surface of the element—420 + 110 = 530 mm. This section of the steam jet between the ribs will be 2,150 square mm. The efficiency of superheat for section A will thus be $k = 530 \div 2150 = 0.24$.

Each square unit of superheating surface concentrated in a ribbed section A, with respect to the efficiency of superheat,

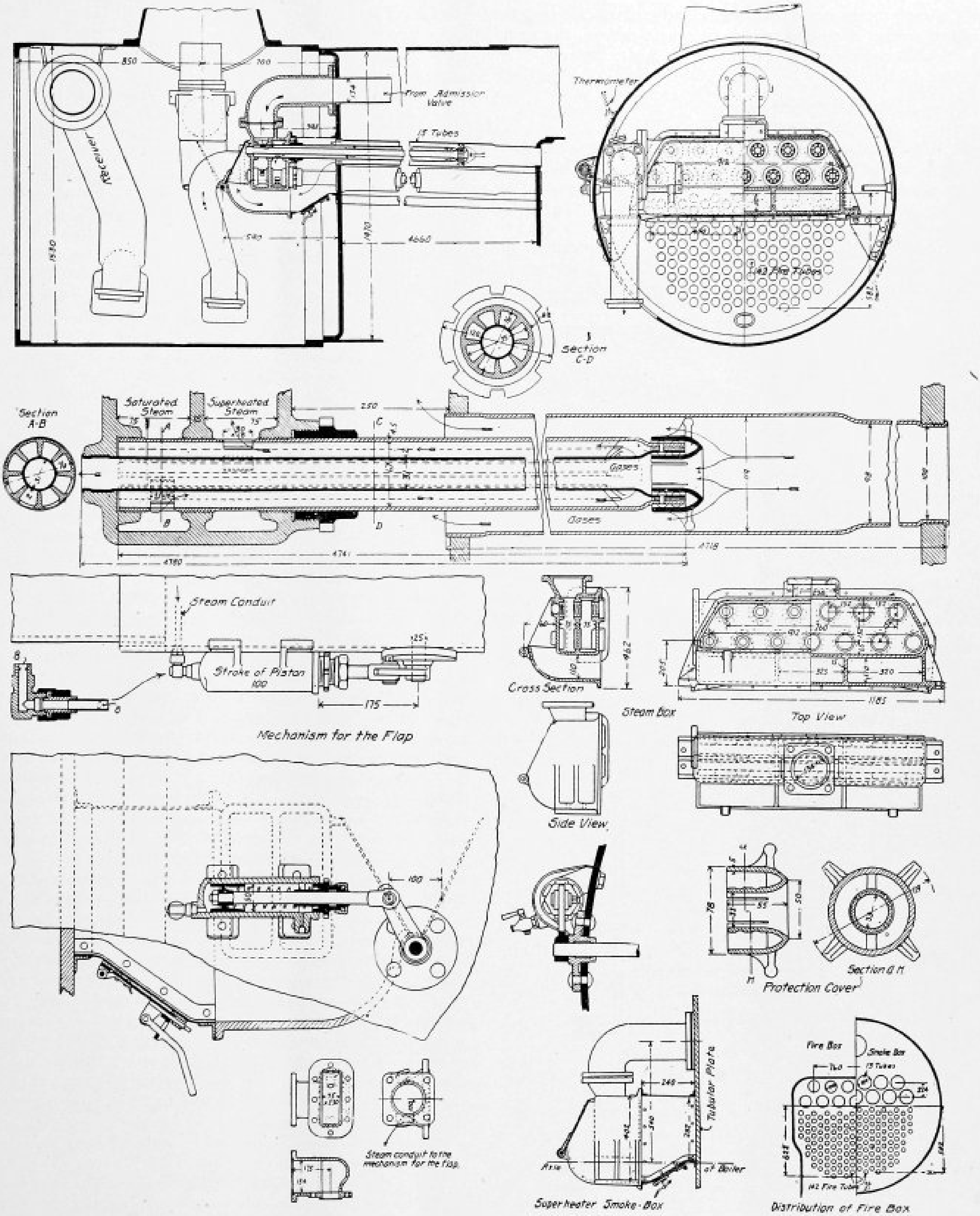


FIG. 2.—DETAILS OF NOTKINE SUPERHEATER.

With reference to a round section, the efficiency of a ribbed one will be more by

$$\frac{0.24 - 0.16}{0.16} \times 100 = 50 \text{ percent.}$$

will be equivalent to 1.5 times the same units of a round section B.

In locomotives and marine boilers it is naturally a matter of great importance to concentrate a maximum of efficient superheating surface in a minimum of the boiler volume, in order to reduce the loss of heating surface in the fire tubes to a minimum.

On each meter run of a fire tube 119 mm. in diameter, the ribbed section *A* concentrates 0.530 square meters; the round section *B* concentrates $4 \times 78.5 = 0.314$ square meters.

The difference is

$$\frac{0.530 - 0.314}{0.314} \times 100 = 68.7 \text{ percent.}$$

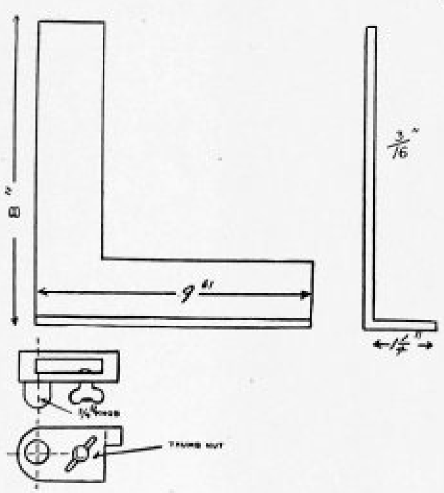
In the section *A* is thus concentrated in the same boiler volume an absolute superheating surface 68.7 percent more than in the case where section *B* is used. As the efficiency of *A* exceeds the efficiency of *B* by 50 percent, we come to the conclusion that with reference to the efficiency of superheat, the boiler volume is used by $68.7 + 0.50 \times 68.7 = 103$ percent better and more economically with elements of section *A* in comparison to elements of section *B*.

The construction of the whole superheater is shown in Fig. 2 so clearly that no further explanations are needed beyond noting that the elements of section *A* are screwed into the walls of a steam box made of cast steel. This superheater appears simple and cheap of construction, safe for working, tight in piping points, requires very little attention, easy to inspect and clean. The jointing arrangements of the piping appear particularly well worked out. It will be noted that all dimensions are given in millimeters, of which 25.4 make one inch, and 305 make one foot.—*Page's Weekly.*

Flange Square.

There is a very ingenious tool used in the boiler shop of the Canadian Pacific Railway in Vancouver, B. C., and it has been designed and patented by Mr. A. McFee, the foreman boiler maker at that place. It is a square and is intended for the work of laying out the holes in the flange of a tube sheet or the inside back sheet of a fire-box or the round head at the front end.

When one of these sheets has to be renewed, the usual way is to place the old and the new sheet on a face plate and



lay out each hole by transferring the distance of each from the table, measured on the old sheet, to the new sheet by the use of a rule, a pair of calipers and a scriber. The process is more or less tedious and there is a certain chance of error in the transferring process.

The flange square, as it may be called, is a neat little tool which very much facilitates process just described. It consists of an accurately made square formed out of 3-16-inch boiler plate. It has a flange on one side which permits it to stand in a vertical position on the face plate or laying-out table. There is a slide which neatly fits the upright arm of the square and on this there is a knob which just fills the old rivet holes in the flange of the sheet which is being measured and different slides with suitable knobs may be used for different sized holes, in various plates, but the principle is the same in each case. The notch in the right-hand side of the slide permits the knob being placed low down so as to fit into a hole as close to the edge of the flange as need be.

The way this tool is used is to stand it on the face plate and apply to a tube sheet or any flanged plate which is on the table. The sheet lies with its flange downward, and the new and similar sheet is on top. The knob fits into a rivet hole in the original sheet and the slide is then clamped by turning a thumb nut. This firmly holds the slide, and when a line is drawn along the upright arm of the square on the new sheet it gives the center line of the new rivet hole.

The vertical center line of each hole is thus accurately scribed on the new sheet, and the horizontal distance from the outer edge of the flange for each hole is taken off in the usual way with a pair of calipers.—*Railway and Locomotive Engineering.*

Boiler Plate Corrosion.

Boiler plate corrosion is the subject of a bulletin recently prepared by Messrs. Ch. Fremont and F. Osmond, and published by de la Societe d'Encouragement pour l'Industrie Nationale, Revue de Metallurgie, of Paris. The assumption is made in the bulletin at the start that acids alone have the power of inducing oxidation in iron, and that it is most likely carbonic acid, which actually produces this change, while oxygen only serves to raise the first-formed protoxide to a higher degree of oxidation. It is also assumed that the hammering or working of the metal renders it more liable to attack by this corrosive action than originally. The local corrosions in steam boilers are classified in two groups: Those taking the form of pustules or pitting, and those giving rise to striations or fissure-like marks. The characteristics of both groups are discussed, but the bulletin has to do only with the latter group, which are considered to probably be due in the first instance to certain mechanical causes. The corrosions taking the striated form, it has already been observed by Mr. Desgeans, are met with in certain parts of the boiler plates, where the metal has to undergo a series of flexure, resulting from the successive expansion and contraction of the boiler when in service, and that the fatigue of plates thus subjected may possibly have a great influence in producing these results.

It is shown that if a homogeneous plate were covered with a uniform layer of oxidation, gradually increasing in thickness, since the coating is practically incapable of deformation, a time would come when the elastic flexure of the plate itself would effect the rupture of this coating of oxide. Such rupture would occur in the locality where the fatigue was greatest, and would follow the lines of the direction of the resultant of the force tending to produce such flexure. This rupture in the coating would leave an exposed surface of the metal to be attacked again by the corrosion, and to be in turn, ruptured, thus eventually forming a crack in the plate.

Micrographic investigations were made of iron and steel plates from four locomotive boilers of the Western Railway of France. The result of these investigations were in accordance with those of the experiments made some time ago by Messrs. Sidney A. Houghton and F. Rodgers, which later results were presented before the Iron and Steel Institute. In numerous cases the results coincided with the assumptions that had been made. A wavy appearance in the microstructure of certain specimens investigated with regard to the causes of boiler explosions is believed to be due to imperfections in the polishing and the mode of attack.—*Engineering Record.*

HOW TO LAY OUT A TUBULAR BOILER.

PART I.

BY H. S. JEFFERY.

In this layout of an ordinary tubular boiler, one which is generally rated as an 80-H. P. boiler has been selected, as being a standard size. It is 60 inches in diameter by 14 feet long. It is desired to give as complete a description as possible of the design and layout of this boiler, using several different formulæ to show how each point is found. The object of this is to give some idea of the necessity of having all boilers constructed under some law or authority. Under present conditions boilers can be constructed from mere ideas, and this results in some parts of the boiler being unnecessarily strong, while other parts are too weak. Many of the mysterious boiler explosions result from this class of construction.

In computing the allowable working pressure of the boiler, we will first have to find out what pressure is required to suit the needs of the particular plant where the boiler is to be installed. Let us assume that our customer has placed an order with us for a boiler to be constructed for a working pressure of 150 pounds per square inch, but expressly states that at times he will need a pressure of 175 pounds per square inch. He figures that in time he may need this additional 25 pounds pressure, so he orders his boiler accordingly. The object in bringing this out is to show purchasers of boilers that it is a wise idea when installing new boilers to have them constructed for a greater pressure than they need at the time of purchasing, as there is always a tendency to use more pressure rather than less. It is not to be expected that the majority of plant owners know how to figure out whether these boilers are safe for the pressure they are carrying. Consequently, advantage is taken of their ignorance in this respect. Instances are known where it was desired to increase the pressure of a boiler, and a boiler maker was called in to see if the boiler could stand an increased pressure. After he had made a general survey, or bird's-eye view of the boiler, he advised the owners that it would be safe to do so, and they acted accordingly. The majority of parties who authorize this increased pressure do not know one item about figuring out the safe working pressure of a boiler.

An idea seems to prevail that the more rivets there are in a seam the stronger the joint will be. We will see how this works out in specific cases a little further along. Another feature to be considered is the factor of safety. Some use 4, others 5. A set factor is all right providing it specifies in detail how the work is to be done using that factor, but the grade of work should be taken into consideration in deciding the factor. Therefore, to encourage good work we should have different percentages, that we can add, covering each operation where work may be slighted. The very best of construction consists of drilling all holes and having longitudinal seams made with double-butt strapped joints. If the holes are not drilled in place, the next best construction is punching the holes small and reaming out from ⅛ inch to 3/16 inch after the sheets are in place.

How to Ascertain the Factor of Safety.

When cylindrical shells of boilers are made of the best material (either iron or steel), with all holes drilled in place, the plates afterwards taken apart and the burrs removed, and all longitudinal seams fitted with double-butt straps, each at least (⅝) five-eighths the thickness of the plates they cover, the seams being double riveted, with rivets 75 percent over single shear and having the circumferential seams constructed so the percentage is at least one-half that of the longitudinal seams, and provided that the boiler has been open for inspection to the government inspector during the whole period of construction; then 4 may be used as a factor of safety. But when the above conditions have not been complied with, the conditions in the following scale must be added to the factor 4, according to the circumstances of each case:

A = .1—To be added when all holes are fair and good in longitudinal seams, but drilled out of place after bending.

B = .2—To be added when all holes are fair in longitudinal seams, but drilled before bending.

C = .2—To be added when all holes are fair and good in longitudinal seams, but punched after bending.

D = .3—To be added when all holes are fair and good in longitudinal seams, but punched before bending.

*E = .7—To be added when all holes are not fair and good in longitudinal seams.

F = .07—To be added if the holes are all fair and good in the circumferential seams, but drilled out of place after bending.

G = .1—To be added if all holes are all fair and good in the circumferential seams, but drilled before bending.

H = .1—To be added if the holes are all fair and good in the circumferential seams, but punched after bending.

I = .15—To be added if the holes are all fair and good in the circumferential seams, but punched before bending.

*J = .15—To be added if the holes are not fair and good in the circumferential seams.

K = .2—To be added if double-butt straps are not fitted to the longitudinal seams, and said seams are lap and double riveted.

L = .07—To be added if double-butt straps are not fitted to the longitudinal seams, and said seams are lap and treble riveted.

M = .3—To be added if only single-butt straps are fitted to the longitudinal seams, and said seams are double riveted.

N = .15—To be added 'f only single-butt straps are fitted to the longitudinal seams, and said seams are treble riveted.

O = 1.—To be added when any description of joint in the longitudinal seam is single riveted.

P = .2—To be added if all holes are punched small and reamed afterwards, or drilled out in place.

Q = .4—To be added if the longitudinal seams are not properly crossed.

*R = .4—To be added when material or workmanship is in any way doubtful, and the inspector is not satisfied that it is of best quality.

S = 1.—To be added if boiler has not been open for inspection during the whole period of construction.

NOTE.—When marked with an (*) the factor may be increased still further if the workmanship or material is such as in the inspector's judgment renders such increase necessary.

NOTE.—Steam Boiler Inspection Act, 1901, for British Columbia, Canada.

The following examples will serve to show how the factor may be determined for any given case:

Lap, treble riveted, holes punched full size before bending:

4.00
.30 = D
.15 = I
.07 = L
——
4.52 = Combined factor.

To this is every possible chance of having to add $E = .7$ and $J = .15$, this then would make the factor 5.37.

Lap, treble riveted, holes punched small, being drilled or reamed out in place:

4.00
.20 = P
.07 = L
——
4.27 = Combined factor.

In this method we are able to drop both D and I and bring in P, making a difference of .25 in percentages. It also cuts out any chance of E or J being added in, and it is the best method that can be exercised with a lap treble riveted joint, having holes punched before bending. From ⅛ inch to 3/16 inch should be drilled out of each hole.

Treble-riveted butt joint, with holes punched full size:

4.00
.30 = D
.15 = I
——
4.45 = Combined factor.

To this there is every possible chance of having to add $E = .7$ and $J = .15$. This would then make the factor 5.30.

Treble-riveted butt joint, with holes punched small, being drilled or reamed out in place:

4.00
.20 = P
——
4.20 = Combined factor.

In this method we are able to drop both D and I and bring in P, making a difference of .25 in percentage. It also cuts out any chance of E or J being added in, and it is the best method that can be exercised other than holes drilled in place. The reaming should be not less than ⅛ inch in diameter.

It will be noted that with holes drilled in place we can use a factor 4, providing we have double-butt straps at the longitudinal seams, but with the same joint with holes punched small and reamed out, the combined factor is 4.27. The latter will be generally used on account of the punching being so much cheaper, even though heavier plates might be required.

In order to calculate the allowable working pressure of a boiler it is necessary to know not only the factor of safety but also the efficiency of the riveted joints, since a riveted joint is always weaker than a solid plate, and therefore the pressure allowed a boiler must be less than would be the case if the shell were one solid plate with no joints. The efficiency of the joint is the ratio of the strength of the joint to the strength of the solid plate. The strength of the net section of the plate after the rivet holes are cut out is figured, and also the shearing strength of the rivets is figured. Then the smaller of these values is used as the strength of the joint to be used in the ratio. Different laws have given various formulæ of slightly different form for figuring the efficiency of a joint, as will be seen from the examples given below. These do not give exactly the same results, as different conditions and assumptions were used in deducing them.

According to the practice of the Hartford Steam Boiler Inspection & Insurance Company, the efficiency of a riveted joint would be found as follows:

Treble Riveted Lap Joint.

Steel plate, tensile strength per square inch of section 60,000 pounds.

Thickness of plate, 7/16 = .4375
Diameter rivet holes, 15/16 = .9375
Area of one rivet hole = .69029
Pitch of rivets, 3 15/16 = 3.9375

Shearing resistance of steel rivets per square inch 42,000 pounds.

3.9375 × .4375 × 60000 = 103,359 pounds = strength of solid plate,

$$3.9375 - .9375 = 3.00.$$

3 × .4375 × 60000 = 78,750 pounds strength of net section of plate.

3 × .69029 × 42000 = 86,976.54 pounds strength of three rivets in single shear,

$$100 \times 78750 \div 103,359 = 76 \text{ percent}$$

efficiency of joint. See Fig. 1.

The British Columbia formula gives the following results:

P = Pitch of rivets in inches.
D = Diameter of rivets in inches.
A = Area of one rivet in square inches.
N = Number of rivets in one pitch (greatest pitch).
Y = 23 for steel rivets and plate.
Y' = 28 for steel rivets and plate.
T = Thickness of plate in inches.
C = 1 for lap.
C = 1.75 for double-butt strap joint.
F = Factor of safety.
% = Percentage of plate between greatest pitch of rivets.
%' = Percentage of rivet section as compared with solid plate.

$$\frac{100 \times (P - D)}{P} = \% \text{ for iron or steel plates.}$$

$$\frac{100 \times A \times N \times Y \times C \times F}{4 \times Y' \times T \times P} = \%' \text{ for steel plates rivets.}$$

$100 (P - D) = (3.9375 - .9375)\ 100 = 3 \times 100 = 300.$
$300 \div 3.9375 = 76\ \%$ net section plate between rivets.

$$\frac{100 \times .69029 \times 3 \times 23 \times 4.20}{4 \times 28 \times 3.9375 \times .4375} = 104\% = \text{percentage of strength of rivets compared to plate.}$$

NOTE.—F in this example is factor on longitudinal seam only.

The computation, according to the Canadian marine law, is given below:

$$\frac{(\text{Pitch} - \text{diameter of rivet hole}) \times 100}{\text{Pitch}} = \% \text{ of strength of plate, at joint, compared with solid plate.}$$

$$\frac{(\text{Area of rivets} \times \text{number rows of rivets}) \times 100}{\text{Pitch} \times \text{thickness of plate}} =$$

% of strength of rivets as compared with solid plate.

Taking the same example, when we obtain 104 percent with B. C. formula, we find as follows:

$$\frac{.69029 \times 3 \times 100}{3.9375 \times .4375} = 120 \text{ percent.}$$

NOTE.—It will be noticed that the Canadian marine law does not take into consideration the factor of safety as is done in the British Columbia law. Also in the formula for the percentage of strength of the rivets as compared with the solid plate, no account is taken of the fact that the shearing strength of the rivets is different from the tensile strength of the plate. Assuming that the shearing strength of the rivets is 42,000 pounds per square inch, and the tensile strength of the plate 60,000 pounds per square inch, then the percentage strength of the rivets, compared to the solid plate, is 84 instead of 120, as given by the formula. In the British Columbia law this has been taken care of by the constant factors in the formula. Thus our percentage with 7/16 plate, treble-riveted lap joint ⅞ rivets, 15/16 holes is 76 percent in each instance, as the net section of the plate was found to be weaker than the strength of the rivets.

$$\frac{60000 \times .76 \times .875}{60 \times 4.52} = \frac{16,625}{1.13} = 147$$ pounds allowed with holes punched full size before bending. All holes being perfectly fair.

$$\frac{60000 \times .76 \times .875}{60 \times 4.07} = 163$$ pounds allowed with all holes drilled in place.

NOTE.—F is the combined factor in these examples.

Just to give some idea of the pressure allowed on the same

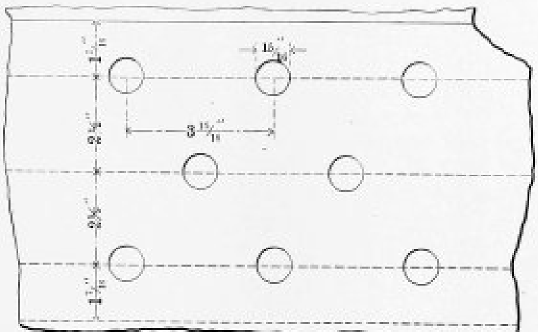


Fig. 1

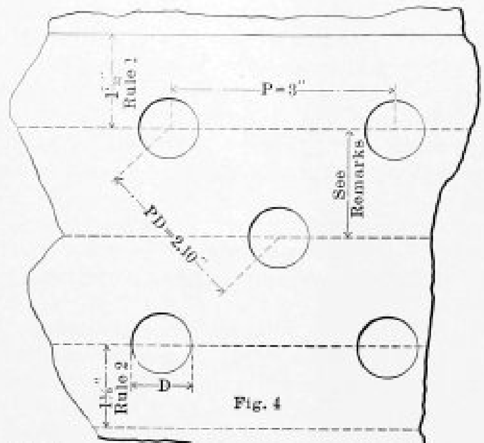


Fig. 4

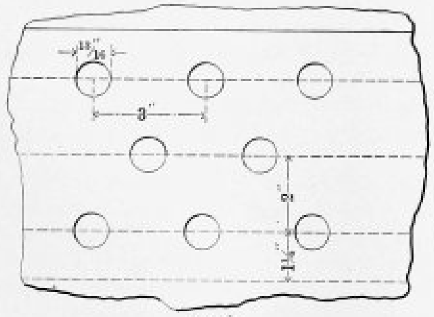
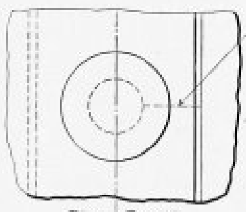


Fig. 2


Plan (Fig. 5)

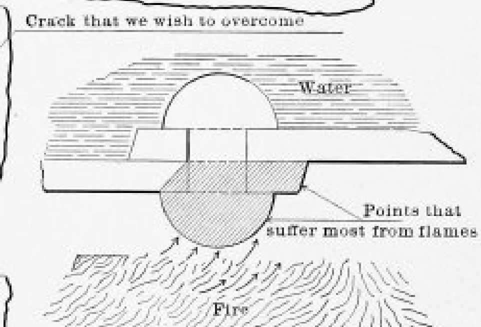


Fig. 5

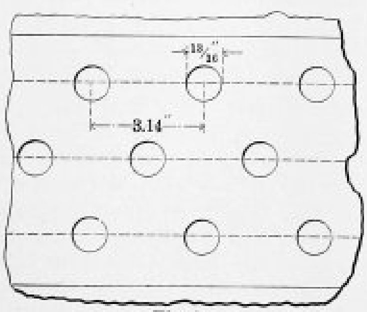
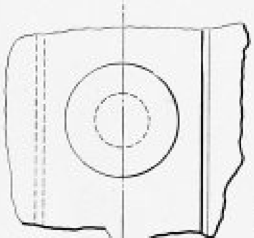


Fig. 3


Plan (Fig. 6)

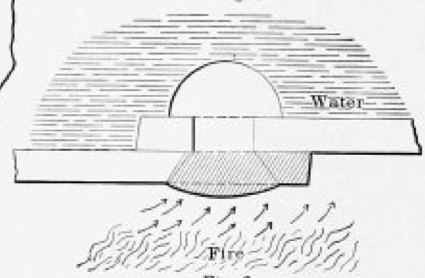


Fig. 6

The Boiler Maker

To get the allowable working pressure for a given thickness of plate for this joint we figure as follows:

$$\frac{T\,S \times R \times 2T}{D \times F} = B$$

TS = Tensile strength.
T = Thickness.
D = Inside diameter of boiler.
F = Factor of safety.
R = Percentage of joint.
B = Working pressure per square inch.

$$\frac{60000 \times .76 \times .873}{60 \times 4.27} = \frac{665.0}{4.27} = 156$$ pounds allowed with holes punched small and reamed out in place.

boiler, with the same joint and pitch of rivets, but having the holes punched full size and more or less of them in the circumferential and longitudinal seams, not fair or good, the following is given: As the extent to which they are blind, will have the effect of deciding just what should be added to the factor, this is left to the inspector. The British Columbia laws would bring the factor up to 5.37, or even greater, if the inspector considered the work such as to warrant it. Assuming 5.37 as a factor we figure as follows:

$$\frac{60000 \times .76 \times .875}{60 \times 5.37} = 124$$ pounds.

Thus we see just what effect the workmanship has on the factor and amount of pressure that can be allowed. It is possible with a treble-riveted lap joint to get 76 percent efficiency and build boilers good for 163 pounds pressure. Yet another boiler constructed with the defects which have been pointed out will, when completed, look as well and get just as high a pressure. Thus we see the great importance of government inspection and laws covering construction of boilers. Let us also figure this same style of joint with ¾ rivets instead of ⅞, and we will see what effect it has in the efficiency of the joint.

Treble-Riveted Lap Joint.

Steel plate, tensile strength per square inch of section, 60,000 pounds.

Thickness of plate, 7/16 = .4375

Diameter rivet hole, 13/16 = .8125

Area of one rivet hole = .5185

Pitch of rivets = 3 inches.

Shearing resistance of steel rivets per square inch = 42,000 pounds.

$3 \times .4375 \times 60{,}000 = 78{,}750$ pounds, strength of solid plate.

$(3 - .8125) \times .4375 \times 60{,}000 = 57{,}421.875$ pounds, strength of net section of plate.

$.5185 \times 3 \times 42{,}000 = 65{,}331$ pounds, strength of 3 rivets in single shear.

$57{,}421.875 \div 78{,}750 = 73$ percent efficiency of joint. See Fig. 2.

It might be asked how the pitch of rivets is decided. No set pitches can be stated for every joint, but a maximum pitch can be stated. While it is true the greater the pitch the greater will be the percentage of the net section of plate, but at the same time the percentage strength of the rivets, compared to the solid plate, is decreasing. It is this weakness that makes the single and double-riveted lap joint longitudinal seams low in efficiency, and makes them unsuitable for boilers of large diameters and pressure. It will be seen the efficiency of a joint with ¾ rivets, 3-inch pitch is 3 percent weaker than a joint with ⅞ rivets, 3 15/16-inch pitch.

By the Canadian marine law and British Columbia formula the pitch may be ascertained as follows:

$$(C \times T) + 1\tfrac{5}{8} = PM$$

T = Thickness of plates in inches.

PM = Maximum pitch of rivets in inches not to exceed 10 inches.

C = Constant applicable from the following table::

No. of Rivets in One Pitch.	Constant for Lap Joint.	Constant for Double Butt Strap Joint.
One	1.31	1.75
Two	2.62	3.50
Three	3.47	4.63
Four	4.14	5.25
Five		6.00

For a treble-riveted lap joint with 7/16-inch plate, ¾-inch rivets, and 13/16-inch rivet holes, the pitch will be found as follows:

$(3.47 \times .4375) + 1.625 = 1.518 + 1.625 = 3.143$-inch pitch.

Therefore, the percentage of the net section of the plate to the solid plate will be

$$\frac{100 \times (3.143 - .8125)}{3.143} = 74 \text{ percent.}$$

NOTE.—See Fig. 3.

It will be seen with these formulæ we do not get the same percentage in net section with ¾ rivets as we did with ⅞ rivets. The maximum pitch, 3.14 inches, was used. If we use 3-inch pitch, as was done with the preceding example, the percentage of the net section of the plate will be a fraction less, but the percentage of the rivet area will be greater.

It might be asked whether it is possible to design a seam for a double-riveted lap joint, with any size of rivets, that will permit the same working pressure as in the preceding problems. Let us see if this is possible. First, we know our rivet area will be less, so we will use a larger rivet, with a view of getting the necessary rivet area. We will use a 15/16 rivet in our example.

Steel plate, tensile strength per square inch of section, 60,000 pounds.

Thickness of plate, 7/16 = .4375

Diameter of rivet holes = 1 inch.

Area of rivet holes = .7854

Pitch of rivets, 3 5/16 = 3.3124

Shearing resistance of steel rivets per square inch, 42,000.

$3.3124 \times .4375 \times 60{,}000 = 86{,}887$ pounds, strength of solid plate.

$3.3124 - 1 = 2.3124$

$2.3124 \times .4375 \times 60{,}000 = 60{,}700$ pounds, strength net section of plate.

$.7854 \times 2 \times 42{,}000 = 65{,}973.6$ pounds, strength of two rivets in single shear.

$60{,}700 \div 86{,}887 = 70$ percent efficiency.

Assume that the holes are punched small, as in the treble-riveted lap joint, and see just what pressure we can allow.

$$\begin{array}{r} 4.00 \\ .20 = P. \\ .20 = K. \\ \hline 4.40 = \text{Combined factor of safety.} \end{array}$$

$$\frac{60000 \times 7 \times .875}{60 \times 4.40} = 139 \text{ pounds allowable working pressure.}$$

156 pounds treble-riveted lap joint, with ⅞-inch rivets.
139 pounds double-riveted lap joint, with 15/16-inch rivets.

17 pounds difference under same conditions.

Thus we see what efficiency and allowable pressure can be obtained with a treble-riveted lap joint, and also the decrease in these which will occur in a boiler with only a double-riveted lap joint. We also ascertain how important it is for the factor of safety to be set according to the actual conditions of holes, etc. We further see the value of all holes being reamed, so that the factor of safety is not allowed to increase. A high factor is not necessary with good work.

A question most liable to be asked is, what distance should there be between the rows of rivets, as well as the amount of lap from center of rivet hole to calking edge. The distance between the rows of rivets is not very important, as it will have no bearing on the efficiency of the joint. It is well not to have too great a distance, because of the trouble in keeping the seam tight. Again, it must not be too small, so that one rivet head laps upon another. A good idea is to make the diagonal pitch about equal to the pitch of a single riveted lap seam. This permits the rivet sets or dies to perform their work without cutting the head of an adjoining rivet, and also brings the sheets close together, making a tight joint with a slight amount of calking.

Rule—

$$\frac{6P + 4D}{10} = PD.$$

P = Pitch of rivets in inches.

D = Diameter of rivets in inches.

PD = Diagonal pitch in inches.

If the pitch is 3 inches, with ¾-inch rivets, the diagonal pitch will be found as follows:

$$\frac{(3 \times 6) + (4 \times \tfrac{3}{4})}{10} = 2.1\text{-inches diagonal pitch.}$$ See Fig. 4.

Our readers will understand that PD, which in this example is 2.10 inches, is the minimum pitch, and they are privileged to i crease it, and cause no decrease in the efficiency of the seam. Too great a pitch (PD) will, as explained, make trouble in having a steam-tight job. Many of our readers have, no doubt, frequently seen seams made tight and then break out in spots a little later on. These leaks are caught only to break out in another place. The diagonal pitch in a case of this kind is generally too great.

To Ascertain the Lap.

The amount of lap is varied according to the ideas of those who handle the work. A short lap is desired, when the seam is exposed to flames or heat, so as to prevent the sheets cracking from the rivet holes to the calking edge. The water being unable to reach the sheet and rivet head directly, causes the material at this point to get hotter, resulting in cracks. Therefore, as short a lap as possible is used when the seam is directly exposed to the fire and heat. Some boiler makers have resorted to counter-sinking the rivet holes, and are driving an oval counter-sunk rivet, as shown in Fig. 6. The rule generally used is to make the lap 1½ times the diameter of the rivet hole. This is sometimes varied by taking 1½ times the diameter of the rivet, which, of course, gives a slightly smaller lap, as the diameter of the rivet is 1/16 inch less than the diameter of the hole.

(To be Continued.)

Locomotive Flue Welding.*

Flue work in our railroad shops is one of the important classes of work, as much so as locomotive frames, rod work, motion work or the different classes of locomotive work which we take up from year to year. Our association has taken it up right along and some improvement has been shown at the conventions when the subject was considered.

IN THE METHOD OF WELDING, SHOULDERING AND EXPANDING FLUES.

Our first aim should be to get a solid weld. This is the most important of all operations. In regard to shouldering or expanding, there is no question, as these operations are worked from the solid end and need no special care only to get to the sizes.

The welds, on the other hand, must not be defective. If they are defective and show a leak after being put in the boiler, the flues must be taken out and all work done on that flue gone over again, which doubles the cost on every flue that is defective, not counting the delay of holding the engine out of service, which is quite an item sometimes on that account.

The second point is the output. To get a good output, a fair day's work is what we are duty bound to do, in order to hold a good record and satisfy our company and keep our shop up to or ahead of any other shop. We should get good average day's work every day.

We do not consider these grandstand plays made on exhibition and made to show what can be done by the different kinds of tools and furnaces to be a fair average, for the work done on those trials is not up to the standard of what we must do right along. We have seen some of those tests made which did not show a good quality of work done, but showed great speed, or how fast a certain furnace would heat and how fast a certain machine could weld flues.

THE DIFFERENT METHODS OF PREPARING FLUES AND WELDING SAME.

Some shops, after the flue is cut off, scarf the flue and safe end by machine back about ½ inch to a thin edge, and then weld. Other shops scarf under their welding machine and then weld both the safe end and flue. This practice has been followed for years.

While a great many shops of to-day have abandoned the idea of scarfing either the flue or safe end as an operation, yet when the flue and safe end are cut off, they are cut by a disk or round cutter, beveled on one side and straight on the opposite side, so that when the flue or safe end is cut it leaves the end beveled ready for welding. This does away with the expense of scarfing. When the flues and safe ends are cut this way it leaves them scarfed at no cost and there is no waste of metal as there are no cuttings.

In welding the flues and safe ends that are cut in this way, there is a mandrel, that is tapered at one end, placed alongside of the welding furnace. The flue welder's helper puts the flues right from the cutter into the furnace, gets the end hot, shoves it up on the mandrel, which opens out the end. He has his safe end laying in the furnace, returns the flue to the furnace and pulls the safe end back into the flue and continues to heat for the welder. The furnace has two heating holes. The helper keeps the flues ready for the welder as fast as he welds and shoulders. On an ordinary safe end he welds and shoulders at one heat.

The method of cutting the flues this way leaves a short bevel or scarf, which, when put together, makes a nice solid weld from the fact of giving you plenty of metal right through the weld, and you must work the metal in and down to size. This makes a good job.

One practice we want to call your attention to is the crossbar at back end of furnace that is intended to jump or upset the flue against when it is hot, before taking same to the hammer or welding machine to be welded. This is important, as it puts the safe end back against the flue and upsets it where it is welded, and there is where you need the material.

We have found some flue welders who seemed to be in a hurry and would not take the time to jump the flue when hot against this bar. We do not think this is good practice, as we believe that flue work should not be slighted.

PRACTICAL SUGGESTIONS.

For a flue shop, where it can be done, it seems to be the old custom on flue work to have the rattler or cleaner in some out-of-the-way place, and the cutting-off machine in another place not very convenient to the welder. This causes the flue to be carried from the truck to the cleaner or rattler and from the rattler to the cutting machine, and after cutting carried again to the welder and very likely from the welder back to the cutting machine again to be cut to length. All of this carrying is costly and unnecessary if it can be avoided.

The new plan which is in practice and is found to be a good plan, is to place the flue shop in line with the rattler, which is at one end of the shop and high enough above the ground so that the flues when rattled can be dropped out from under the rattler and roll to the flue cutter on inclined rails. When the cutter cuts them and drops them down, they then roll to the welder. They are welded and shouldered; then they are dropped down and roll to another cutter, which cuts them to length and then they roll to the expander, if you expand them. All is done and not one was carried or costs a cent for portage through the flue shop, being handled only by the operator. The flue is not even turned around, but goes straight through to a finish, there being two cutting machines, one at each end of flue and one placed close to rattler, the other placed after the flues leave the welder.

No person touches the flue after the rattler is opened, so far as portage is concerned, until the flue is carried to the engine, it being handled only in cutting and welding.

FUEL FOR HEATING FLUES USED AT PRESENT.

Hard coke has been the old reliable, but it has seen its day as it costs too much to handle it, and we lose too much time in cleaning the furnace and wheeling out the ashes, and the

* A paper presented before the convention of the Railway Master Blacksmiths' Association.

output is too small. Fuel oil and natural gas are doing great work both in quality and output.

(Signed) G. H. JUDY,
GEO. KELLY,
R. LAIZURE,
J. B. BLOOM,
M. COPPS.

Elementary Problems in Laying Out.

CYLINDRICAL SURFACES.

Cylindrical surfaces are laid out by a method of parallel lines; for instance, in developing the surface of the cylinder shown in Fig. 7, proceed as follows: Draw a half view of the plan and divide the semi-circumference into any number of

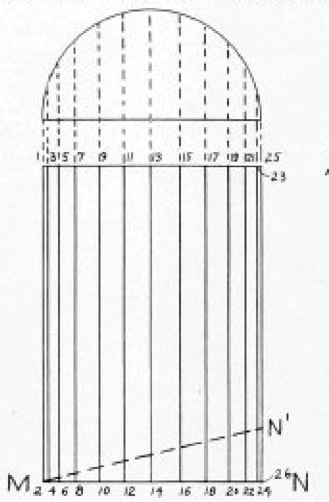


FIG. 7.

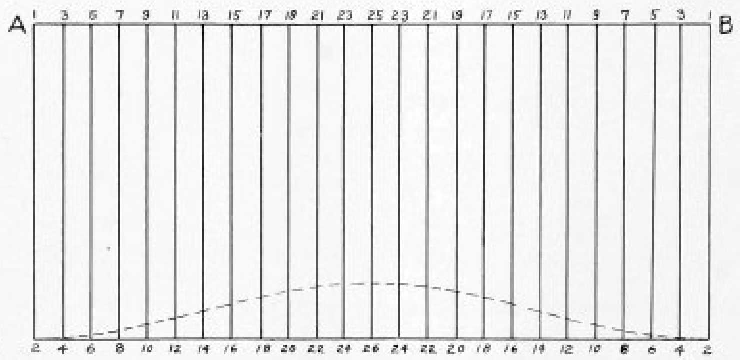


FIG. 8.

equal parts, in this case twelve. Project lines down from these points of division upon the cylinder. Lay out the line *AB*, Fig. 8, equal to the length of the circumference of the base of the cylinder and divide it into the same number of equal parts into which the base was divided; in this case twenty-four as the semi-circumference was divided into twelve equal parts. Draw lines at right angles to *AB* at these points and lay off along them the lengths of the corresponding lines in Fig. 7. When each base of the cylinder is at right angles with the axis as in Fig. 7, all of these lines are equal so the developed surface will be a rectangle. If the base *MN* had been inclined as *MN'*, then the length of each of the parallel lines would have been different and it would have been necessary to measure each line separately and lay it out on the corresponding line in the development. Then the bottom edge of the developed surface would have the form shown by the dotted line in Fig 8, the numbers showing the corresponding lines on the cylinder and development.

Before taking up the actual layout of a cylindrical boiler or tank shell, the apprentice must first be able to find the circumference of a circle in order to get the length of the plate corresponding to the distance *AB* in Fig. 8, as this line was made equal to the length of the circumference of the base of the cylinder. The circumference of a circle is equal to 3.1416 times its diameter. If the apprentice is not familiar with the use of decimals, the same result may be obtained by multiplying the circumference by 22 and dividing by 7. In nearly all engineers' and boiler makers' hand-books, tables are given, in one column of which are values of diameters, and in another column the corresponding values of the circumferences of the circles, and in a third column the values of the areas of the circles. The area of a circle is equal to 3.1416 times its radius squared. The use of such tables will greatly reduce the labor of computation and the chances of making mistakes.

As the material used in boiler construction has considerable thickness, it will be apparent that when a plate is rolled up in the form of a cylinder, the diameter at the inside of the plate is less than the diameter at the outside by twice the thickness of the plate; therefore, the circumference corresponding to the inside diameter will be considerable less than that corresponding to the outside diameter. When laying out the plate it will be seen that neither of these values for the circumference should be used for the length of the plate, as one would be too short and the other too long; but the circumference of a circle, whose diameter may be called the neutral diameter or the diameter to the middle of the thickness of the plate will be the correct one to use. Thus, in Fig. 9, if a half-inch plate is to be rolled to a cylinder whose inside diameter is 48 inches, the plate must be laid out with a length between the center lines of the rivet holes equal to the circumference of a circle whose diameter is $48\frac{1}{2}$ inches,

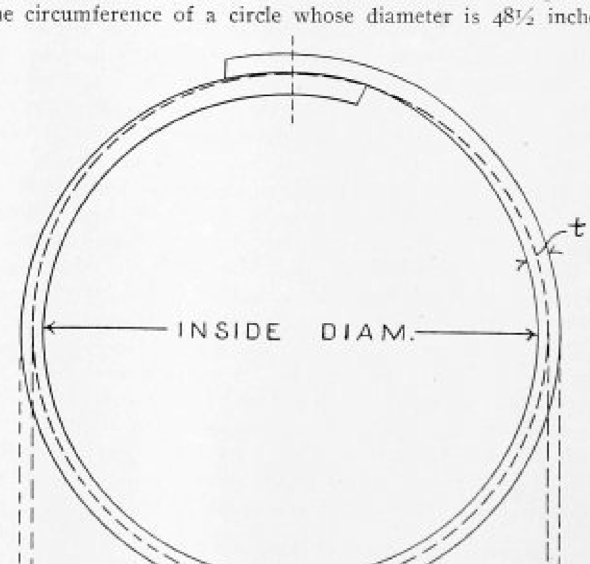


FIG. 9.

or referring to Fig. 9, it will be seen that if $t =$ the thickness of the material and D the inside diameter, then the neutral diameter is $D + 2 \times \frac{1}{2} t$ or $D + t$. Therefore the circumference corresponding to this diameter is $3.1416 \times (D + t)$ or

3.1416 D + 3.1416 t. That is, it is equal to the circumference corresponding to the inside diameter plus 3.1416 times the thickness of the plate. For ordinary work three times the thickness of the plate is generally used. The circumference corresponding to the outside diameter might have been found, in which case three times the thickness of the plate should have been subtracted from it. When two rings or courses of plates are to be joined together, one of which is an inside and the other an outside ring, the circumference corresponding to the neutral diameter of the inside ring may be found, and then for the length of the outside plate six times the thickness of the material should be added to this. This will make a close fit between the rings, as the exact amount to be added is 2 times 3.1416 or about 6¼ times the thickness of the material. For an easy fit, add a little more to this. This amount can best be determined from the experience of the layer out for the particular job in hand. In the case of a straight stack, with in and out rings, where there is no pressure upon the shell and the work is not to be water-tight, seven times the thickness of material can be added to the length of the inside ring for the length of the outside ring.

Bearing in mind the foregoing manner of determining the length of the rings of a cylindrical shell and the allowances to be made due to rolling the material, let us consider the lay-out of the shell of the pressure tank shown in Fig. 10. This tank is 36 inches diameter and 12 feet long, excluding the heads. It is to be made of three rings of 5-16-inch plate with double-riveted lap joints for the longitudinal seams and single-riveted lap joints for the circumferential seams, all rivets to be ¾ of an inch in diameter. The width of each ring as shown on the drawing is 4 feet between the center lines of the rows of rivets. Lay out the plates to dimensions taken through the center lines of the rivet holes, and afterward add the necessary amount for laps.

First, lay out one of the end or outside plates. As each ring forms a cylinder whose bases are at right angles with its axis the development will be a rectangle similar to the first development in Fig. 8. Therefore it will not be necessary to draw the parallel lines. The width of this plate between the centers of rows of rivets is 48 inches. The length must be computed from the diameter of the ring. The drawing indicates that the inside diameter of this ring is 36 inches. The circumference corresponding to a diameter of 36 inches is 113 1-16 inches.

```
  3.1416
      36
  ------
  188496
  94248
  ------
113.0976 or 113 1-16 inches.
```

Add three times the thickness of the plate or three times 5-16, which equals 15-16. Therefore, the length of the plate between the centers of the rivet lines is 114 inches. Having found these dimensions lay out the plate as follows.

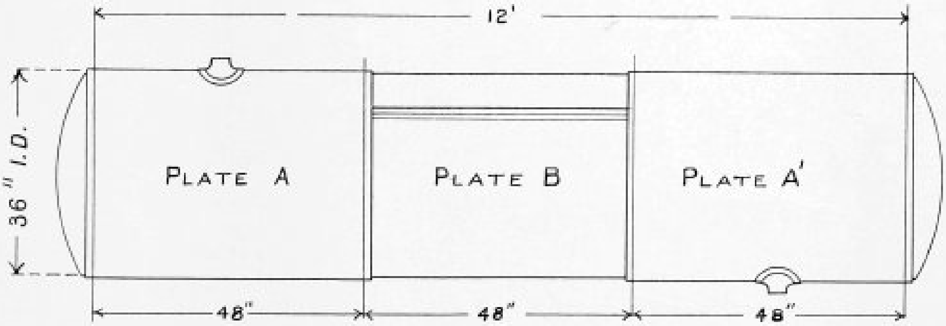


FIG. 10.

First, draw the line *AB* for the lower row of rivets 1¼ inches from the edge of the plate. Then measure from one end of the plate along the line *AB* 1¼ inches for the lap. From this point measure 1 15-16 inches for the second row of rivets. Now, lay off from this point along *AB* 114 inches as shown by the dimensions on Fig. 11. Measure back from this point 1 15-16 inches for the second row of rivets at this end of the plate. Draw the line *CD* 48 inches from *AB*. Now, square up the plate by the method previously explained and draw in the rivet lines for the longitudinal seams. Space in the rivet holes about 3 inches between centers. As the length of the circular seam is 114 inches, a 3-inch pitch will give just thirty-eight spaces in the circular seam.

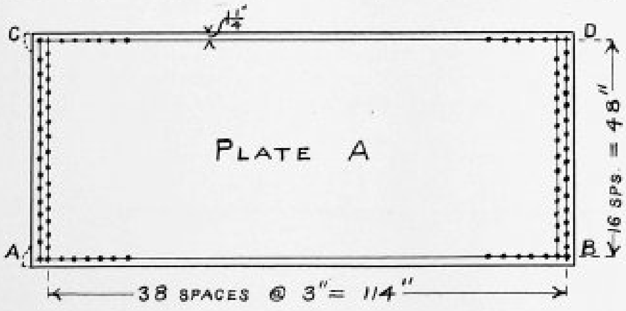


FIG. 11.

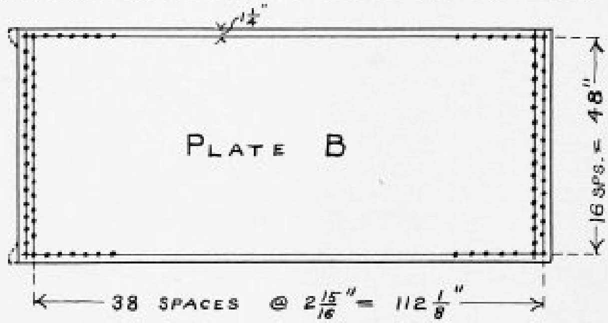


FIG. 12.

The length of the longitudinal seam is 48 inches, so there will be sixteen equal spaces using the 3-inch pitch. As this seam is double riveted, the rivet holes should be staggered as shown in the detail Fig. 13. Care should be taken to see which end of the plate will come outside when the plate is rolled up so that the outer row of rivets at this end of the plate can be spaced equally. The rivet holes in the other row may be conveniently located by setting the dividers to the diagonal pitch, and then with the centers of the holes, which have been equally spaced as centers, strike intersecting arcs as shown in Fig. 13. When the end of the plate comes between two other plates at the corners the plate should be drawn out thin or scarfed. As this plate is an outside ring, the corners of the end which comes inside at the lap should be scarfed as indicated by the dotted lines in Fig. 11.

The layout of the inside ring is similar to that of the outside, except that the length between the centers of the rivet holes is less than that of the outside plate by six times the thickness of the material. As the plate is 5-16 inch thick, six times the thickness will be 1⅞ inches; therefore, the length of this plate should be 114 inches minus 1⅞ of 112⅛ inches. The pitch of the rivets in the circular seam will not be the same as

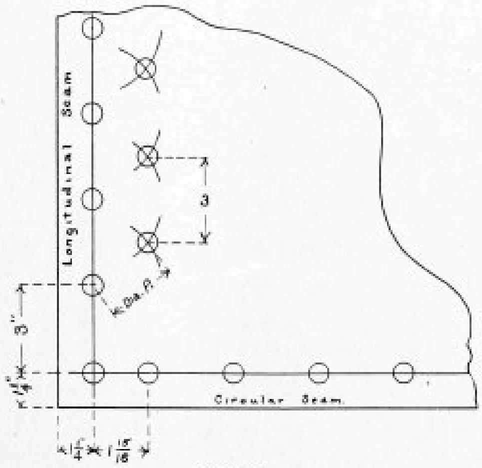


FIG. 13.

in the outside plate, since the number of spaces must be the same. As this is an inside ring, the corners of that end of the plate, which comes outside at the lap when the plate is rolled up, should be scarfed as indicated by the dotted lines in Fig. 12.

The layout of the heads has not been given in this article, neither have the nozzles in plates *A* and *A′* been located, as this layout was given simply to show the method of getting the sizes of the plates which form a cylindrical surface.

LAYOUT OF AN OPEN TANK.

Fig. 14 shows an open tank 6 feet wide by 4 feet deep (inside dimensions) and 15 feet long between the center lines of

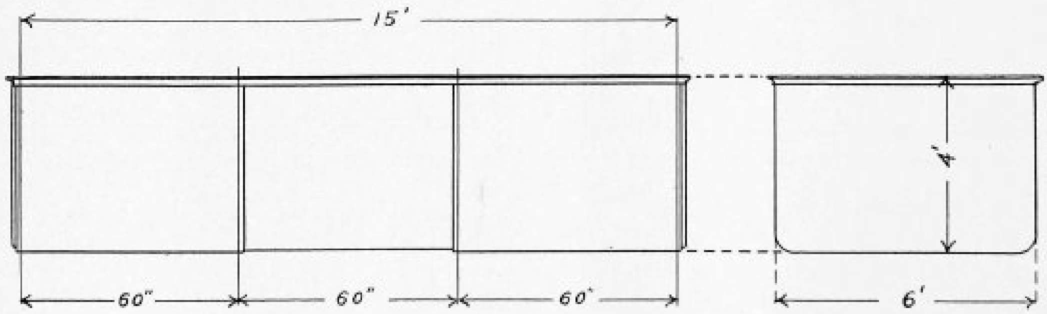


FIG. 14.

the rivet holes in the heads. This tank is to be made of three courses of ¼-inch plate joined together by single-riveted lap seams, the rivets being ⅝ inch in diameter. The radius of the curve at the corners of the tank is 6 inches. The heads are to be flanged.

First lay out one of the end or outside plates, a sectional view of which is shown in Fig. 15. It will be seen that the length of this plate is equal to 3½ feet (the length of the flat part of the plate at the side), plus one-quarter of the circumference of a circle of 6⅛ inches radius, plus 5 feet (the length of the flat portion of the plate at the bottom) plus one-quarter of the circumference of a circle of 6⅛ inches radius, plus 3½ feet (the length of the straight portion of the other side). The length of the curved or cylindrical part must be computed as follows.

Since the inside radius at the corner is 6 inches and the thickness of the plate ¼ of an inch, the neutral diameter of the

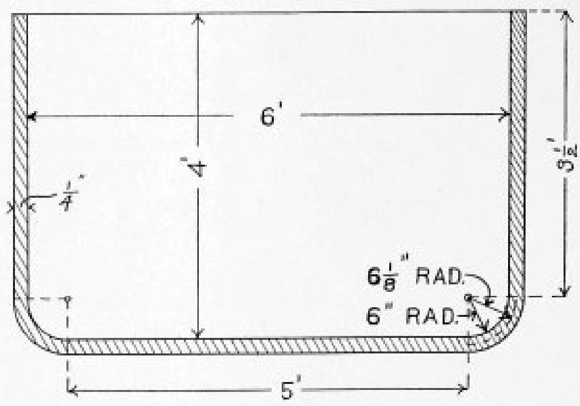


FIG. 15.

cylinder, of which this forms one-quarter of the surface, will be 12¼ inches. Therefore, the length of one-quarter of the circumference corresponding to this diameter will be

```
 3.1416
   12¼
-------
  62832
 31416
-------
 37.6992
   .7854
-------
 38.4846
```

$$\frac{38.4846}{4} = 9.6212'' \text{ or } 9\tfrac{5}{8}''.$$

Now, lay out the plate as shown in Fig. 16. As the rivets are to be ⅝ inch, the lap, which is usually 1½ times the diameter of the rivet, will be about 1 inch. Therefore, draw in a line 1 inch from the longest edge of the plate. Lay off 3½ feet or 42 inches from one end of the plate for the side; then 9⅝ inches for the curved portion; then 5 feet or 60 inches for the bottom, and then 9⅝ inches for the other corner, and then 3½ feet or 42 inches for the other side. Lay out the width of the plate 60 inches. Square up the ends and the flange lines to which the corners are to be rolled. The rivet holes should be spaced in at about 1⅞ inches between centers. Put in the first rivet hole 1 inch from the end of the plate, and then step off the spaces at about this pitch to the flange line at the corner. The same spacing may be used on the other side.

Then step off an even number of spaces in the curved part, changing the pitch if necessary, also step off the spaces on the bottom at as near the same pitch as possible.

For the inside plate, the only difference in the dimensions will be in the length of the curved part at the corner. The neutral diameter for this plate will be 11¾ inches, or the neutral diameter of the outside plate minus twice the thick-

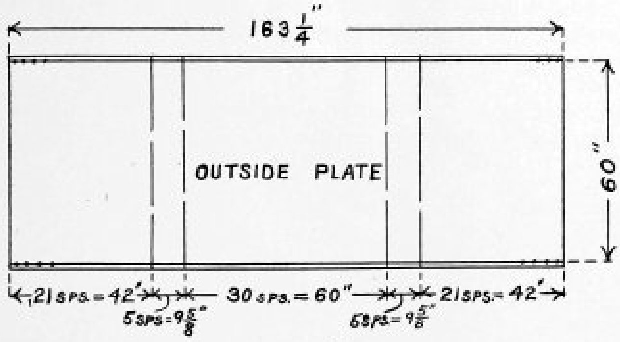


FIG. 16.

ness of the material. One-quarter of the circumference of a circle 11¾ inches in diameter will be

```
      3.1416
        11¾
    --------
      31416
     31416
      23562
    --------
     36.9138
```

$$\frac{36.9138}{4} = 9.2285'' \text{ or } 9\ 7\text{-}32''.$$

This gives us then 9 7-32 inches as the length of this part of the plate. The spacing of rivets in the flat portions of the plate

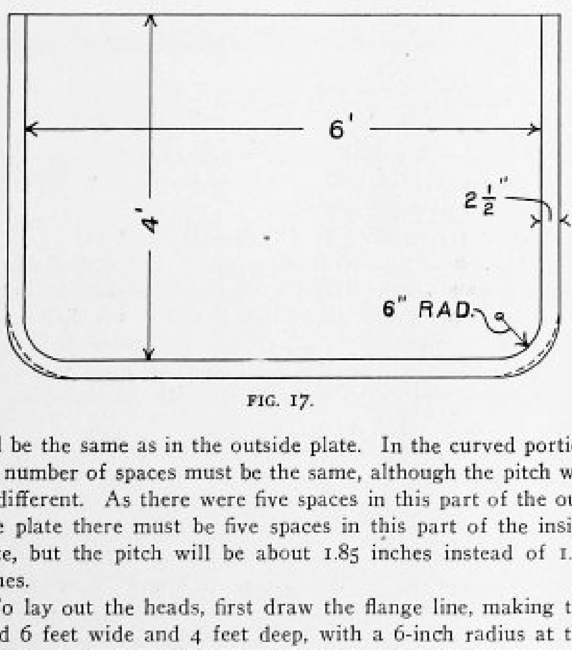


FIG. 17.

will be the same as in the outside plate. In the curved portion the number of spaces must be the same, although the pitch will be different. As there were five spaces in this part of the outside plate there must be five spaces in this part of the inside plate, but the pitch will be about 1.85 inches instead of 1.92 inches.

To lay out the heads, first draw the flange line, making the head 6 feet wide and 4 feet deep, with a 6-inch radius at the corners. We will assume that the flange is to be 3 inches deep. As the metal will be drawn down at the curved part of the flange, it will not be necessary to leave 3 inches to make this flange. Subtract from the depth of the flange twice the thickness of the plate, giving us 3 inches minus ½ inch, or 2½ inches as the distance from the flange line to the edge of the plate. At the corners the plate should be sheared off in some such manner as indicated by the dotted lines, Fig. 17, as there will be too much material in the corner when it is flanged over, and by cutting the plate, as shown, some of this will be removed. After the plate is flanged the rivet line can be drawn and the holes spaced to correspond with the holes in the adjoining plate.

This tank will need angle-bars along the top edges to stiffen it. As these are simply straight bars, it will not be necessary to show how they are laid out.

While the foregoing problems are in themselves simple, they represent some of the common everyday work which an apprentice must learn to do accurately before attempting to lay out more complicated surfaces, where it will be necessary to make use of the principles of orthographic projection. Having mastered these elementary principles for finding the sizes of plate which are to be rolled to form cylindrical surfaces, he will then more readily understand the more complicated layouts which are to follow.

Heating of Boiler-Feed Water by Exhaust Steam.

BY CALVIN B. ROSS.

The heating of the feed-water before it enters the boiler is an important factor in the economy of any steam-generating plant.

In all plants, even those run condensing, there is available the exhaust from the steam-driven auxiliaries, which if not used for heating will waste to the atmosphere; and how many realize the vast amount of saving which might be effected with a small investment, an outlay for installation which will pay for itself over and over again?

Every steam plant under ordinary conditions has an abundant supply of exhaust steam available for the heating of feed-water, as from feed-pumps, etc., and there is surely no more profitable use to which such exhaust can be put. The above becomes evident when attention is called to the fact that the weight of exhaust steam required to bring the feed-water temperature up to the boiling point varies from 1-16 to 1-10 that of the feed-water.

In some instances the only units running non-condensing are the boiler feed-pumps, which may not furnish sufficient quantities of "vapor fuel" to bring the feed-water up to the required temperature. Under these conditions it surely is economy to run one or more vacuum or condenser pumps non-condensing, thereby increasing the efficiency of this quantity of steam above that when operating these pumps condensing. In short, always provide sufficient exhaust steam for preheating the boiler feed-water, which is economy beyond dispute.

So much for the statement of facts, now for the proof. The advantages to be derived from an exhaust steam feed-water heater and purifier may be divided into three general classes as follows:

Economy,
Purification,
Protection to boilers.

In plants operating without the use of a feed-water heater, the highest ordinary temperature at which water will be delivered to the boilers is that of the hot-well; usually about 100 degrees F. Now this is far from the temperature to which it is necessary to raise the water before the point of vaporization is reached, necessitating the expenditure of positive heat.

Now the product of the number of pounds of water per hour and the difference in temperature between the raw water and water at 210 degrees, which is about as high as can be obtained in a heater, gives the number of British thermal units necessary to perform this work. From the table of properties of saturated steam may be found the heat value of 1 pound of exhaust steam in British thermal units, and dividing the number of British thermal units required, as determined above, by the tabular value per pound, gives the number of pounds of steam necessary to heat the feed-water. Knowing the ratio of evaporation to coal consumed and the calorific value of coal, the saving thus effected will become apparent.

Without going into further detail, let me state from authority that the relative cost of using feed-water at any one temperature as compared with the use of water at any other temperature, is as the reciprocal of their factors of evaporation. Thus if feed-water can be supplied by means of a heater at 210 degrees F., where previously drawn from the mains at 50 degrees F., the relative cost of making steam will be, at say 100 pounds pressure, by gage,

$$\frac{1043}{1208} = 0.86$$ and a gain of 14 percent will be effected.

Or by another method of calculation, if the total heat of steam minus the heat of the cold feed = X, and the total heat of steam minus the head of the feed = Y, then $X—Y$ gives the units of heat per pound of feed-water, saved by preheating by waste heat. Then the saving in percentage will be:

$$\frac{X - Y}{X}$$ when expressed decimally.

Even when the exhaust is used in connection with a heating system, a heater may be inserted in the line under the same back-pressure as is on the system, for the very small amount of steam necessary to heat the feed-water will in most cases leave an abundance of steam for the heating system. Such a heater also acts in the capacity of a receiver for the returns from traps and heating systems, returning this water to the boilers without additional heat loss. Open heaters of approved design provide an efficient method for the elimination of oil from the steam before the latter enters the heater, thus insuring against the presence of oil in the boilers.

Everyone realizes the importance, and in fact the necessity, of removing scale-forming materials from the feed-water before it enters the boilers. It is much better to catch these impurities upon the outside than to allow them to enter, and by their damaging presence decrease the steam-generating power of the boilers. There is to be found more or less foreign matter, either carried in suspension or solution in most all waters, and methods must be devised for its complete removal before the water is in proper condition for boiler feed. It is another function of heating this water by exhaust steam to remove all solids, crystalizable at exhaust steam temperature; hence an open heater affords a most efficient unit for the performance of such work, being easy for cleaning and inspection.

It is a well-known fact that the effect of cold water entering a boiler in operation is to set up strains and stresses which may cause a leak or fracture. By this pre-heating of the feed-water to almost the point at which evaporation begins, there is no possibility of such trouble. With due consideration for all the facts herein communicated, is it not advisable to make good use of your exhaust steam, which is a money-maker in every sense of the word? for as we have been told, "A penny saved is a penny gained."

The only real expenditure is the original cost of installation, running expenses for cleaning and repairs being small in comparison. No steam power plant of any description can afford to operate without the use of an exhaust heater and purifier, which takes up but little space and can be located at any point regardless of location of boilers.—*Power.*

Layout of a Taper Course, Round at One End and Oblong at the Other.

BY C. LINSTROM

This particular sheet comes up in general boiler making very frequently, and there are two methods for laying it out, namely, triangulation and projection. Since the minor diameter of the oblong end is the same as the diameter of the round end, it can be easily and acurately laid out by projection. It will be noted that in Fig. 3 there is a flat space, indicated by *A*, and the taper is all on one side of the center line.

Fig. 1 shows the object as it sometimes appears in the taper course of a boiler, however, its use is not very frequent, due to

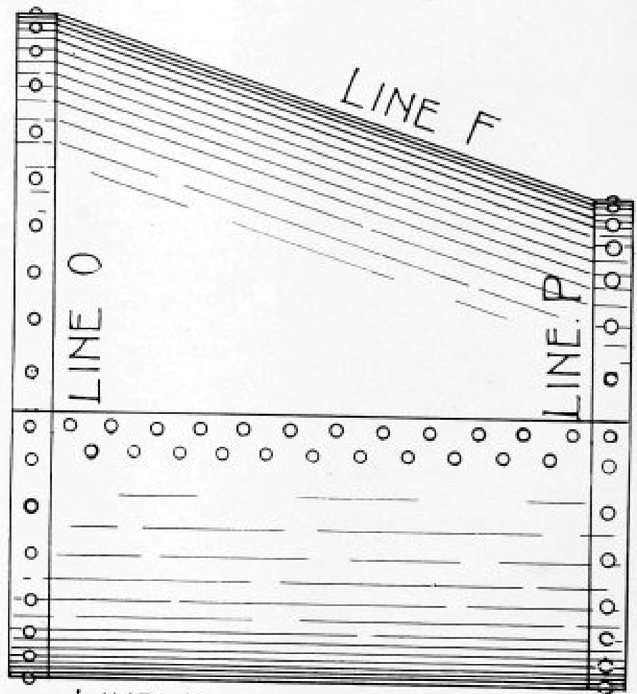


FIG. 1.

the fact that such a form is hard to brace satisfactorily. Shops doing a great variety of sheet-iron work have this object very frequently to contend with.

To lay out our object we will proceed as follows:

First, draw up a side-elevation, and at each end of this elevation draw a half view of the plan of the respective ends as shown in Fig. 3. The center line *R* will be the division line from the top and bottom half. As for the bottom half, it will be seen that this portion is nothing but a sheet rolled to a semi-circle to whatever diameter we wish to make our object.

To layout the top half we strike off the two quarter-circles at each end and divide these quarter circles into any number of equal spaces. In this layout seven equal spaces, numbered from one to eight, inclusive, have been used. From the respective points obtained on the circles we will extend horizontal lines over to the vertical lines *O* and *P*. Having found our points on lines *O* and *P* we now connect these points together with lines running parallel with line *F*. At point *D*, which in this case is the division point between the top and bottom halves, we draw line *E*, extending to line *F*, and this line should be at right angles with line *F*. At the intersection of line *E*, with the slant line obtained from 1 to 1 we find point *C*, this is the center point for the radius which we have in the center of Fig. 3. Due to the shape of our object, this last radius is not the same length as our end radii. Having all the necessary data in we will now proceed to lay out the pattern as in Fig. 4.

First, draw the horizontal line *E*, Fig. 4, full length of the sheet. Locate the center point marked *F*. As we have seven equal spaces in our semi-circle, we will lay off on each side of our center line *F* that number of spaces. It will be seen by referring to Fig. 4 that our pattern is developed on each side of line *F*. We therefore take the lengths of the slant lines,

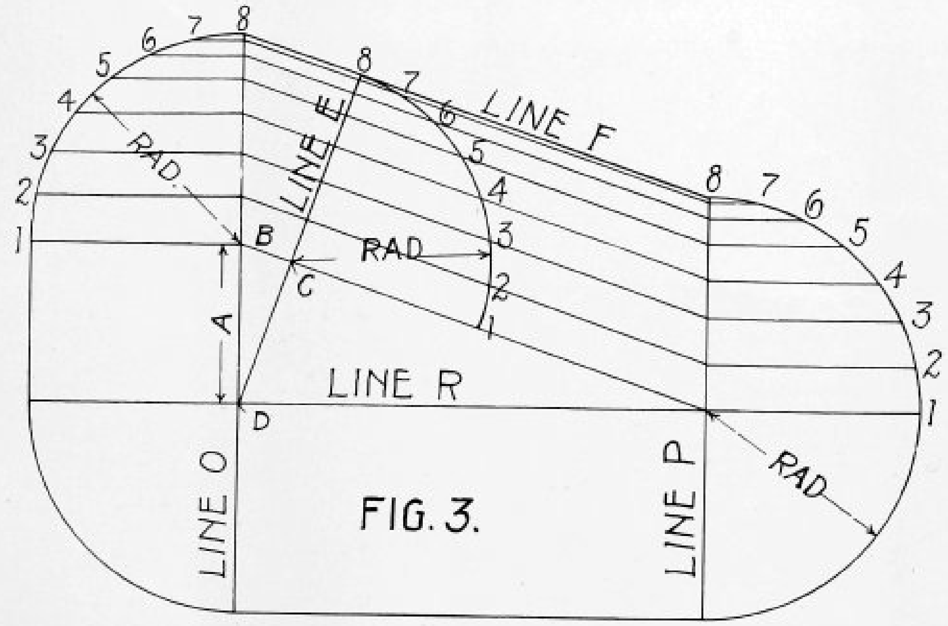


FIG. 3.

Fig. 3, on each side of line *F* and transfer them to the corresponding points Fig. 4. This gives us the center line from 1 to 8, inclusive.

We have the taper or wedge-shaped piece yet to develop.

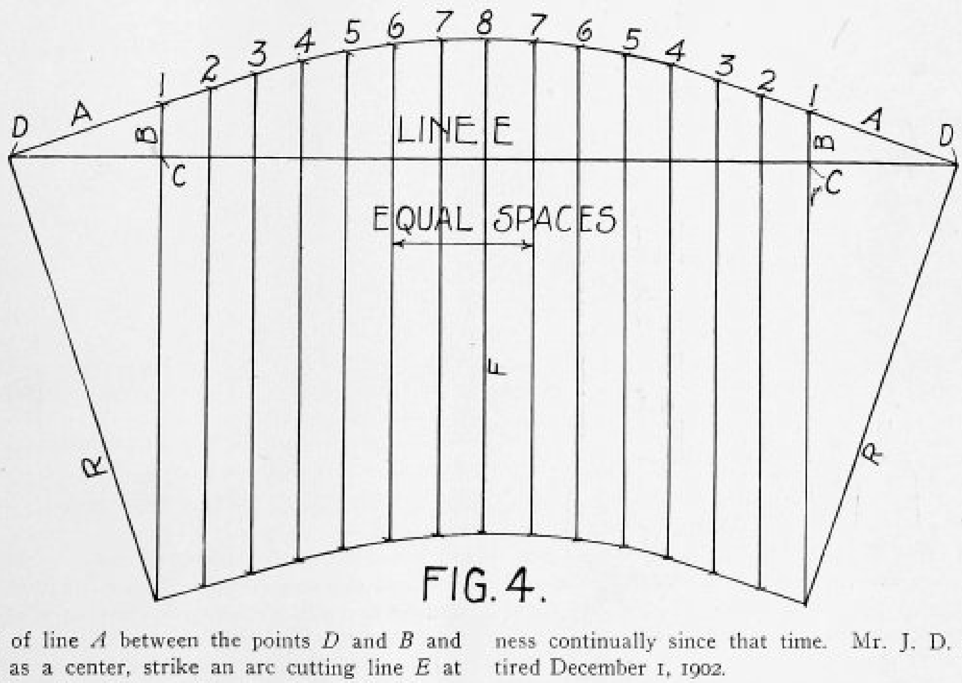


FIG. 4.

Take the length of line *A* between the points *D* and *B* and using *B*, Fig. 4, as a center, strike an arc cutting line *E* at point *D*. Therefore, the distance between *D* and *C*, Fig. 4, should be the same as between *D* and *C*, Fig. 3. Be it understood that the respective radii are struck on the neutral diameter, taking care of the necessary take-up in rolling.

Add for laps, etc., and the layout is complete.

PERSONAL.

MR. H. A. FLAGG has been appointed as manager of sales of the Shelby Steel Tube Company, in charge of their New York office.

The name of the MacKinnon Manufacturing Company has been changed to the MacKinnon Boiler & Machine Company. This change of title, which took place on the first day of December, does not in any way change the stockholders, directors or officers of the company, which was organized in September, 1867, by Mr. J. D. MacKinnon, and has been in business continually since that time. Mr. J. D. MacKinnon retired December 1, 1902.

The joint convention of the Master Steam Boiler Makers' Association and the International Railway Master Boiler Makers' Association will be held at Cleveland, Ohio, May 21, 22 and 23. A very interesting program is being arranged.

New Method of Riveter Installation.

Everybody to-day appreciates the advantage and the necessity of a large riveting machine. However, in many of the smaller shops and in certain places it is not always convenient or expedient, and is often very expensive, to install a vertically-set riveter, with the necessary accessories of tower and building, crane and runway, electrical equipment and other necessary apparatus. In Germany the riveter is often suspended from a specially built trestle, and after this idea the following novel installation has been worked out and built by the Chester B. Albree Iron Works Company, Allegheny, Pa.

The photograph shows a 10-foot 6-inch gap riveter suspended from a trestle work, with an especially-built truck for boilers, since this particular installation is for a boiler plant. The truck can be pinched along by putting a pipe on sprocket wheel for the purpose, and the riveter can be raised or lowered by hand with a small chain block, as it is perfectly counterbalanced. These details are clearly shown in the side and end elevations, Fig. 1. The cost of such an installation will run about one-quarter that of installing a hydraulic riveter with high-pressure pumps, lines, valves, accumulators, usual steel tower, crane, runway, etc. In this case the riveter used is a pneumatic riveter, doing away with the necessity for flexible pipes carrying high-pressure water and the difficulty of carrying away exhaust water, as in this riveter light, flexible hose is used and it exhausts directly into the air. The cost of the above installation shown in the photograph is about as follows:

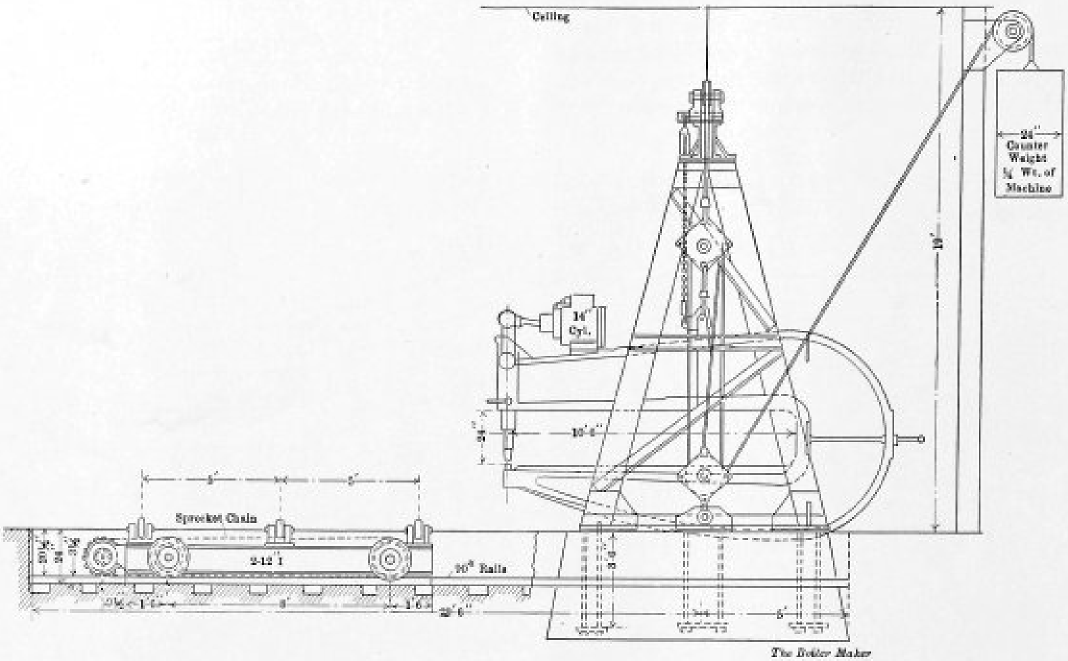


FIG. 1.—SIDE VIEW OF SUSPENDED RIVETER.

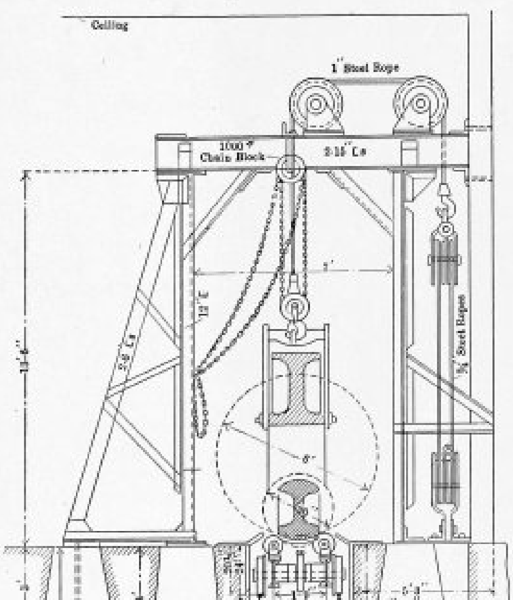


FIG. 2.—END VIEW OF SUSPENDED RIVETER.

Compression riveter, 10-foot 6-inch reach	$1,800
Supports, trestle, truck, etc.	1,100
Foundation, erection, miscellaneous	400
Air compressor and reservoir	600
	$3,900

Of course the riveter could be set vertically, but it would then cost about as follows:

Forty-foot tower, with 25-foot runway, 16-foot span	$1,500
Crane and hoist	1,800
Dynamo and switchboard	800
Compression riveter, 10-foot 6-inch reach	1,800
Air compressor and reservoir	600
Foundation and building changes	1,000
	$7,500

So that this method saves about one-half the first cost of installing a stationary compression riveter and three-quarters the first cost of an hydraulic installation.

The air riveter is coming more and more into use for large work. There is much prejudice in favor of hydraulic power, which is gradually being modified, and when you find a man who has had experience with both in large-sized machines he will say the air machine gives the tighter rivet, as the maximum squeeze comes at the end of the stroke, giving the rivet body time to swell and fill the hole. Such steady increase of pressure throughout the stroke cannot be obtained in the hydraulic machine. The air machine, with its small volume of low-pressure air obtaining pressure by leverage, requires about one-fifth the power per rivet that a hydraulic machine does. Equipping the hydraulic machine with different sized cylinders so that a small cylinder can be used for small rivets, etc., does not help this point, for the air machine has a reducing valve that will give any pressure and the right pressure on the rivet. An air riveter will perhaps average 50 cubic feet of free air per minute, corresponding to about 10 H. P., and valuing horsepower at $40 a year, running daytime only, the cost for power is something like $200 a year. The power bill on a corresponding hydraulic machine would be something like $1,000 per year. Of course, in practice, a machine will not run steadily throughout the year, but where any reasonable amount of work is done, 25 percent or 30 percent of the original cost of the machine can be saved each year.

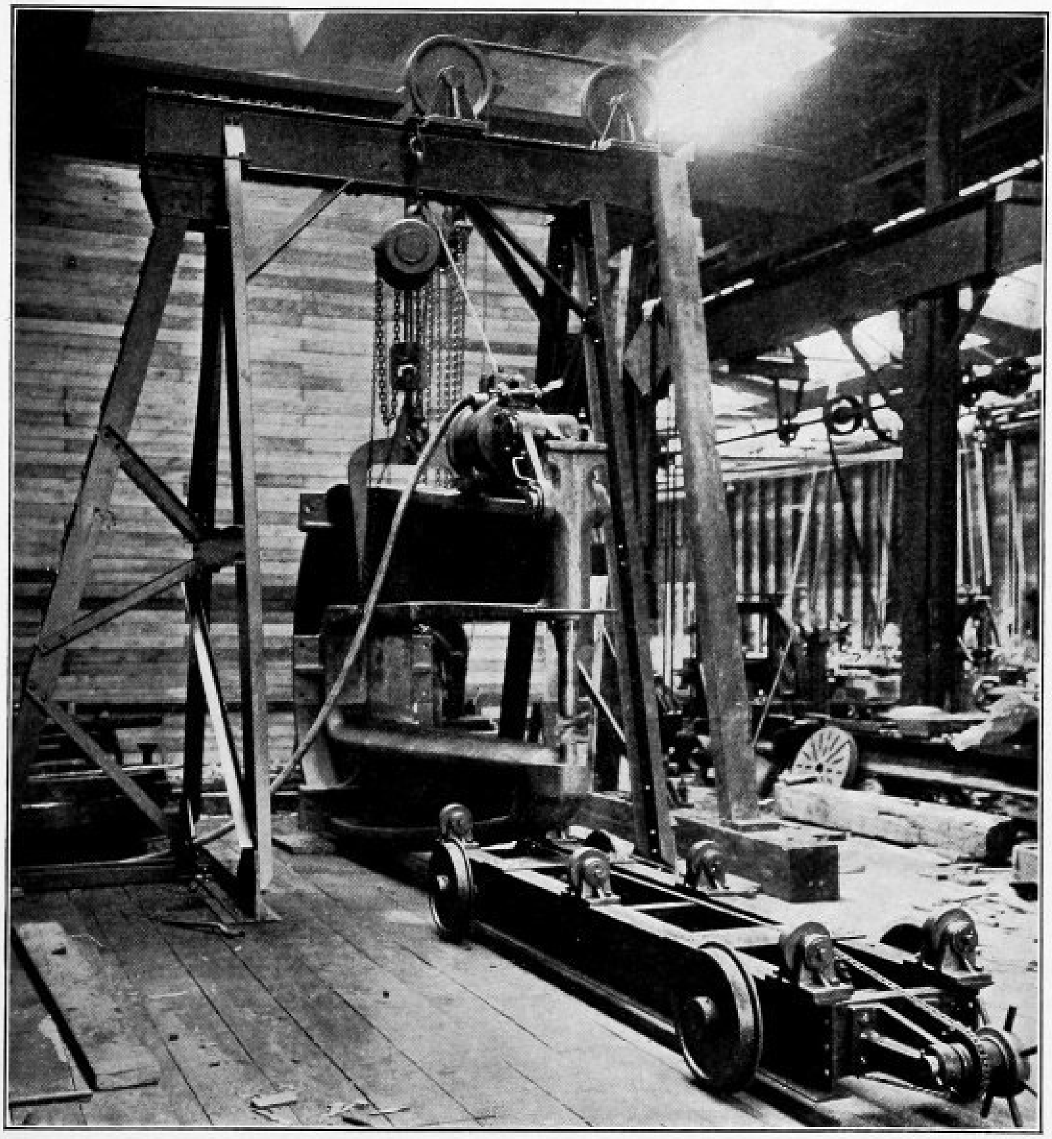


FIG. 3.—RIVETER INSTALLATION FOR A BOILER PLANT.

The combination, therefore, of an air machine with a trestle work not only gives most satisfactory results, but can be both installed and operated very cheaply, and anyone contemplating riveter installations will find it much to their interest to investigate carefully the large air installations now in service.

Flue Spacing.

The opinion that there are too many tubes in locomotive boilers is apparently gaining ground, as may be gathered from some recent examples of new power. It would seem that the question could not long remain open to argument in the face of properly conducted experiment. It is not clear why an attempt has not been made before this time by those most interested, to determine the effect of flue spacing on the steaming capacity of boilers.

No elaborate appliances are necessary to obtain the required information. If it can be shown that close spacing impedes circulation, and there are some good reasons to believe that it does, the remedy is plain. Experiments on this line might yield results by employing tubes of known high conductivity, like the Serve or the spirally-corrugated tube, which, if claims made for them are borne out, could be placed much further apart than is now the practice with plain tubes, and still deliver their heat units to the right spot.

There are two-fold advantages involved in this proposition if correct, namely, better steaming and a reduction of flue troubles, which reduced to their lowest terms, mean fuel economy and less initial and maintenance cost for tubes.—*Railway Master Mechanic.*

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - New York

Christopher St., Finsbury Square, London, E. C.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico........	$1.00	.10
Other countries in Postal Union..........	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

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 5,800 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

The Tubular Boiler.

The article on "How to Lay Out a Tubular Boiler," which appears in this issue, is the first of a series of articles on this subject which is to be published in our columns. This subject is one which cannot fail to be of interest to boiler makers and boiler manufacturers alike, because it is fundamental. The subject is to be treated in a very exhaustive manner, taking up each point in the design, layout and construction from several different points of view, and presenting to the reader what has been found in practice to give the best results in modern boiler construction. The principles which are used in the design and construction of the tubular boiler are common to much of the work done in a boiler shop, so that when thoroughly understood a long step has been taken in understanding boiler making in general.

Boiler Manufacturers' Interests in South America.

A representative of a New York machinery exporting house which makes a specialty of a certain standard make of American boilers, has recently been investigating the business situation on the east coast of South America. His reports seem to indicate that a little aggressive work on the part of American boiler manufacturers would secure for them considerable business in this part of the world. At the present time American interests in that country are intrusted almost without exception to English or German houses. This means that English and German interests are looked after first, while American interests are considered of secondary importance. Practically no aggressive effort is made by these agents to secure business for the American concerns which they represent. If business comes to them without effort, and it cannot be turned into more profitable channels, it is turned over to manufacturers in the United States. It is not that American products are not appreciated, but the need there, as elsewhere abroad, is for American representatives to look after American interests.

Common Knowledge of Boiler Making.

There is much information about boiler making which it takes a long time to learn from work in the shops. Experience is the best teacher, but her methods are often slow, and there would be little progress if a man who has once learned by experience did not give the results of his training to others. There used to be a tendency, and it exists to a slight extent to-day, among boiler makers, to guard jealously such knowledge as placed them in a position above their follow workmen, or at best to impart it to a very few. No one realizes more fully the past difference betwee-nthe position of the man who is able to do a thing on his own responsibility, and the one who must be told how everything is to be done, than the men who are themselves in one of these positions. Young men who start as apprentices in the boiler trade, of course, find themselves in the position of subordinates, and usually are ready and anxious to avail themselves of every opportunity to add to their knowledge of their trade, so that they can rise from the ranks of subordinates to positions of responsibility.

It often happens that in one shop where a young man is obliged to work, there will not be a sufficient variety of work for him to study, and only a few men who are able and willing to teach him much beyond the mere use of his tools. It is for the benefit of such men that we are anxious to publish as much information about the ordinary methods and processes of boiler making, from as many different sources, as possible, because in so doing many new ideas will be brought out, and much which may be common knowledge to a few will be brought to the attention of others as something new.

While the apprentice naturally takes up the study of laying out as being his first step toward promotion, yet it is not entirely from the knowledge or ability to find the development of complicated surfaces that he may expect to make his services more valuable to his employer. The man who, when given a job of repair work, can carry it through upon his own responsibility, determining how the work shall be done, the size of the material which should be used to make the repairs safe without undue waste of material, will find that such knowledge is of great value in practical work. It is strange how few men can be found in a shop who can tell the size of plate, the size of rivets, etc., to be used in placing a patch on an old boiler.

Such work is usually done by the oldest and most experienced men in the shop, because only an experienced man can be relied upon to do the job properly. It is to men who have had such experience that we must look for help in presenting to our younger readers information of this sort. A greater number and variety of the repair jobs come up in a railroad shop where the rough usage of the road multiplies flue trouble, stay-bolt failures, etc. The apprentice in the contract shop finds much that is new and interesting in reports of railroad repair work, and vice versa, the man in the railroad shop will usually find something to his advantage in repairs on stationary boilers.

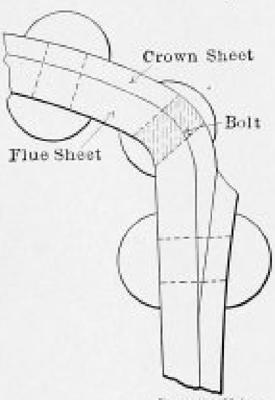
Technical Publication.

Practical Lettering with Original System for Spacing; by Thomas F. Meinhardt. Pages, 16; plates, 2. New York 1906. The Norman W. Henley Publishing Company. Paper covered. Price, 60 cents.

This work has been intended by the author as a practical help for beginners, draftsmen, engineers, engravers, sign painters, stone cutters, lithographers, etc. He has invented a scale by which the letters of a sign or inscription can be spaced so as to give the proper optical effect. The scale and method of using is simple and easily understood from the explanation given in the book. It is of particular value to professional draftsmen or letters where a title or inscription is to be enlarged, as by means of it the exact space which a title will occupy can be accurately found without previous sketching. The book contains valuable hints for pen work and duplicating, also an analysis of the construction of each letter in the alphabet in both Gothic and Roman characters according to the system of spacing explained.

A Communication.

The following has been submitted to the readers of The Boiler Maker: A has a new fire-box flue sheet to put in, and in the corner he puts a ¾-inch bolt with a good thread. The stay was driven in and the outside, as well as the edges, were calked as shown in the sketch. The space between the rivets



was small, yet large enough to require something in the corner. The master mechanic claimed that this was unpractical, but the writer has used this construction many times and has never had any trouble from it. Is this construction practical or would it be better to use a rivet in place of a bolt?

Yours truly,

A Reader.

Shop Talk.

BY CHARLES E. FOURNESS.

EQUALLY PROPORTIONED JAW AND EYE BRACE.

Say body of the brace to be 1⅛ inches diameter. If a jaw is required on one or both ends, the proportions are, the brace pin to be the same diameter as the brace, viz., 1⅛ inches, width of metal outside of the hole on each side and end from ½ to ¾ of the diameter of the brace pin, thickness of the jaw ¾ of the diameter of the brace pin, each side of the jaw proportioned to sustain ⅔ of the load, in order to cover unequal distribution of strains, etc. The proportions are ⅔ of 0.9907 square inch (area of the body of the brace) equals 0.6604 square inch, area of one side. Next find the thickness, ¾ of 1⅛ inches, diameter of brace, equals 0.843 or 27-32 inch. The nearest heavier regular size is ⅞ inch. As each side has an area of 0.6604, this divided by the thickness, ⅞ inch, equals 0.7547 inch, which, plus the diameter of brace pin hole (1 3-16 inches), equals 1.9422, or 2 inches, nearest regular size.

Next, to see if the width is right, there must be a width of material outside of brace pin hole, at sides and end, of ½ to ¾ of the diameter of the brace pin, so the width (if allowing ½ of the the diameter of the pin, so that the two sides include the full diameter) must be taken as the diameter of brace pin, 1⅛ inches, plus the diameter of the pin hole, 1 3-16 inches, which equals 2 5-16 inches least width. This must be considered as the width decided upon, and is all O. K.

Next, if the brace should need a flat end or eye to go into a jaw between the crown bars or angle irons, the proportion should be, brace pin to be the diameter of the body of the brace, 1⅛ inches. The width and thickness the same proportions as for the jaw, from ½ to ¾ the diameter of the brace pin outside pin holes, and thickness never less than ¾ the diameter of the pin.

In an eye or end of this kind, sometimes the width and sometimes the thickness is limited. In this case a greatest allowable width of 2½ inches will be considered. To find width, it is satisfactory to take the diameter of the brace pin, 1⅛ inches, plus the diameter of the brace pin hole, 1 3-16 inches, equals 2 5-16 inches; the nearest regular size is 2½ inches. Now, for the thickness, 2½ inches minus the diameter of the pin hole equals 1.3125; divide the area of the brace, 0.9907 square inch, by 1.3125, which equals the thickness, or .75 or ¾ inch. Now as the brace must be not less than ¾ of the diameter of the brace pin, which is 0.84 or 27-32 inch, the nearest regular size being ⅞ inch.

Equal proportions for a jaw and eye brace; 1⅛-inch body; brace pin 1⅛ inches; jaw ⅞ inch by 2 5-16 inches; eye of ⅞ by 2½ inches.

GUSSET BRACE.

For the strength of a gusset brace, take a brace ½ inch thick and 24 inches wide. The way these braces are usually attached is by two pieces of angle iron on the head and two on the shell. In other cases, when placed between radial stays, the side to be attached to the shell is flanged. If attached by angle irons, the same conditions prevail at each end. In some cases, these ends of the braces are bolted, but generally they are riveted between the angle irons. I will consider a case where they are bolted, which means that the diameter of the bolt must be taken.

Take a brace 24 inches wide at back head and 36 inches long on the shell. This is where judgment fails. In my judgment at least four bolts ⅞ inch in diameter would be needed to equal the brace in strength. Now to ascertain: as these bolts are in double shear, each one will hold 85 percent more than in single shear, or 1.85 times 38,000, which equals 70,300 pounds per square inch. The area of a bolt ⅞ inch in diameter equals 0.60132 square inch, which, times 70,300, equals 42,273 pounds, and four times this amount, as there are four bolts, equals 169,092 pounds.

The brace is 24 inches wide, the diameter of a 15-16-inch hole is 0.9375 inch, which, times four, equals 3.75 inches; 24 inches minus 3.75 inches equals 20.25 inches width of material in the brace, after deducting the diameter of the bolt holes. This width, times 0.5 inch, the thickness, equals 10.125 square inches, the sectional area of the brace. This, times the constant number 8,000 for a plate brace without welds, etc., equals 81,000 pounds. Now 169,092 proper load for the bolts, minus 81,000 load for the brace, shows the brace less than one-half as strong as the rivets, or 88,092 pounds weaker.

Now to find the nearest equal strength, using regular sizes of bolts, etc., using three bolts ¾ inches in diameter, area of one bolt 0.44179 square inch, and three bolts equal 1.32537 square inches; and 70,300 times this equals 93,173 pounds these bolts will hold. Next the diameter of a 13-16-inch hole is 0.8125 inch, and three times this equals 2.4375, which, subtracted from 24 inches, equals 21.5625 inches, which, times the thickness, 0.5 inch, equals 10.78125 square inches. This, times 8,000, the constant, equals 86,250 pounds, which is 9,923 ponds less than the bolts, but nearest practical.

In case the one end is flanged and riveted to the shell, these rivets will be in single shear and will carry 38,000 pounds per square inch if of iron (if of steel 42,000 pounds can be used). As the brace is 1/2 inch, I would advise no less than 7/8-inch rivets be used. The area of a 15-16-inch hole is 0.69029 square inch. This, times 38,000, equals 26,231 pounds held by one rivet, and 86,250 pounds, the strength of the brace, divided by 26,321, equals 3.28, which means that four must be used. The same number would be sufficient to give the required strength for the angle irons on the head, providing the sheet is sufficiently supported.

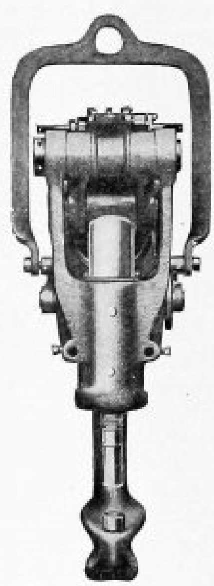
As before stated, the rivet holes in T and angle irons must be drilled not less than 1 1/2 times the diameter of the hole, from the center of the hole to the edge, and the holes in the brace and in the angles where attached to the brace must never be placed less than 2 1/2 times the diameter of the hole, from the center of the hole to the edge. I believe it would be well, before starting on anything else, to show how to find the strength or the amount of strain allowed upon a stay-bolt. Find pressure allowed upon a stay-bolt 1 inch in diameter, cut 12 threads per inch. As the bottom of the thread will be the smallest diameter, and in 12 threads will be 3-32 inch smaller than the plain bolts, this will be 29-32 inch in diameter. The area of this is 0.64504 square inch. This area, times 6,000, which is the constant in this case, equals 3,870 pounds.

I believe I have pretty thoroughly treated on the braces, and will say I have made this as elementary or simple as possible, as it is intended for the people who don't know.

ENGINEERING SPECIALTIES.

The Hanna Special Lattice Riveter.

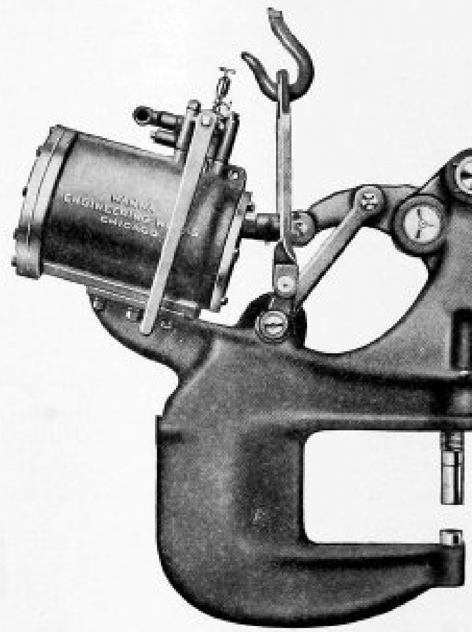
The time has passed when one riveter is expected to do all of the work in a shop. Special machines are now designed for different classes of riveting. The machine which is herewith



END VIEW OF LATTICE RIVETER.

illustrated was produced especially for doing very close lattice work. It will drive a 7/8-inch rivet in 10-inch channels, 4 inches between the flanges. It has a reach of 15 inches and a gap of 12 inches. The frame through the gap is 15 inches wide and 3 3/4 inches at its thickest point, tapering both ways. This permits the riveter to swing from side to side in latticing in the very small space of 4 inches.

This machine is built by the Hanna Engineering Works, 830 Elston Avenue, Chicago, Ill., and has the same mechanical features common to all of the riveters manufactured by this concern. By a combination of toggles, levers and guide links, the large opening of the toggle joint movement with its gradual



SIDE VIEW OF LATTICE RIVETER.

increase of pressure up to the maximum desired pressure is attained, and then by a special lever movement this maximum pressure is available throughout a considerable space.

It will be seen that this combines the advantages of a hydraulic riveter with those of the toggle joint or lever motion. The ideal conditions are obtained in a hydraulic riveter where the maximum pressure is attained, and is available throughout the entire length of the stroke of the plunger, so that a certain known pressure is exerted on the rivet. In an ordinary pneumatic toggle joint machine, a certain maximum pressure is obtained at one point only, and the machine must be adjusted for every variation in the thickness of the plates and length of the rivets. However, in the Hanna riveter, after the maximum pressure has been obtained by the toggle joint, it is retained by means of a lever giving an action similar to that of the hydraulic riveter.

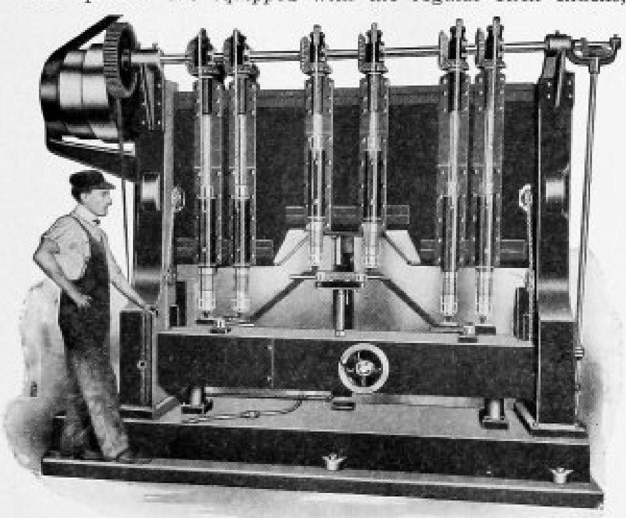
The machine is constructed entirely of steel, with the exception of the cylinder. The working joints are steel pins, working in bronze bushings, except the lower toggle, which is cast steel with ends hardened and ground working in hardened steel buttons. The guides for the ram are brass bushed. The frame is designed to utilize the metal to the best advantage, and to do away as much as possible with springing. The machine has an automatic adjustable cut-off for air on the return stroke, so that the cut-off may be obtained at such a point that the piston will just return to its extreme position. The controlling valve of the cylinder is a plain slide valve with a self-packing stem. The air piston is cushioned at each end.

The Rich Arch Bar Drill Press.

The accompanying illustration shows a Rich arch-bar drill press, manufactured by the George R. Rich Manufacturing Company, Buchanan, Mich. It is usually the case with an arch-bar drill press that the arch bars have to wait their turn on the press, but with this machine it has been found that the machine has to wait for the material. In a recent test 1 3/16-inch holes were drilled in 1¼ inch thick arch bars in 40 seconds. As seen from the illustration, there are six vertical spindles in the machine which can be adjusted in height and width. The maximum vertical adjustment of the center spindles is 9 inches, and that of the end spindles is 17 inches. The maximum distance between center spindles is 20 inches, and the maximum distance between the end spindles is 17 inches. The longest arch bar the machine will take is 7 feet 5 inches.

The feed is obtained by raising the table either by power obtained through the vertical shaft at the right or by the hand-wheel in front. There is a latch-dog beside the hand-wheel, which can be set to stop the feed at any point. The table has a vertical feed of 12 inches, and is thoroughly counterbalanced so that it moves up or down very readily. The greatest clearance from the top of the table at the lowest point to the spindle at the highest point is 24 inches.

The spindles are equipped with the regular Rich chucks,



RICH ARCH BAR DRILL PRESS.

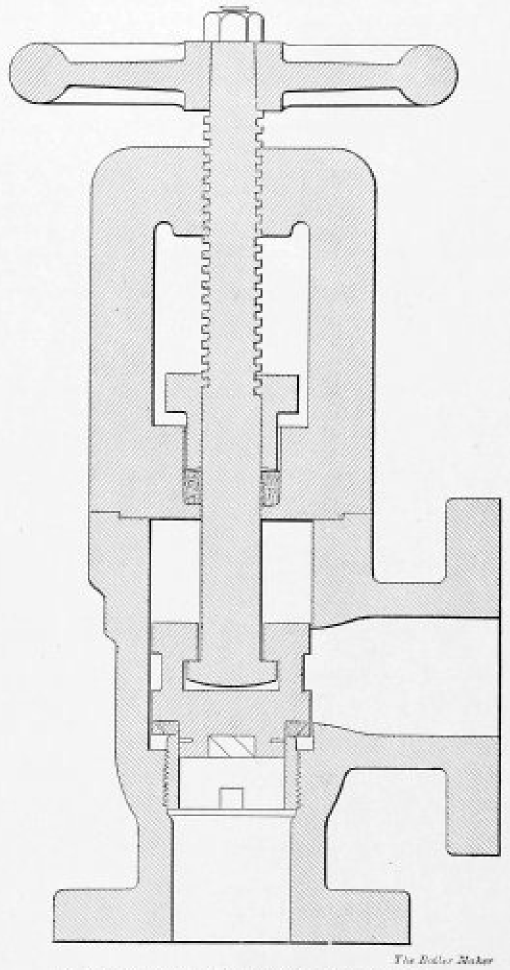
which are furnished to accommodate drills from 13-16 inches to 2 1-16 inches in diameter. The chucks are hollow and all that is necessary to change from one size drill to another is to loosen the cap-screw a little at the bottom and insert any other size drill, which is then held firmly by screwing up the cap. These chucks are also adjustable so as to accommodate various lengths of drills. The drills used are the Rich high-speed flat drill. These are made of high-speed tool steel and are found to be a benefit in work which does not require deep drilling, as only that portion of the drill which the depth of hole requires is exposed to strain. The spindles are set in ball-bearings of 9-16-inch steel balls and the feed-screws in the table are also ball-bearing besides being set in an oil socket.

The machine can be equipped with either belt or motor drive, and has a driving cone whose largest diameter is 24 inches. The machine is fitted with an oil pump and pan around the base. The gears are of steel cut from solid forgings.

The Golden "Clean Seat" Blow-Off Valve.

The Golden "clean seat" boiler blow-off valves are made with screwed and flanged ends. These valves have the same simple and positive feature of "self-cleaning" the seat and disc, that exists in the brass, globe and angle valves manufactured by the Golden-Anderson Valve Specialty Company. They are extra heavy, having an iron body, yoked top and brass mountings.

Referring to the sectional cut interest at once centers in the disc seat and the general substantial construction, also the effective and simple manner of holding in place the yoked top with two large bolts fitted into slotted bolt holes in the body and top. The valve seat is flat and has a narrow surface, having many advantages over any other form. Attention is called to the valve or disc wherein lays the positive self-cleaning feature of the seat and disc. The disc is solid bronze with babbitt or other flexible metal insertion, that can be



SECTIONAL VIEW OF THE GOLDEN VALVE.

quickly refilled if found necessary to do so, as it is designed to slip on or off the spindle when removed from the body of the valve. The bottom of the disc is hollow, with solid, cast eccentric lugs on the side The slot or groove is cut through between the lugs, around the entire outside diameter of the disc, consequently when the slot or groove comes flush with the seat, the water jets directly across the seat and disc, absolutely cleaning them of all sediment just before closing.

The projection on the bottom of the disc performs another important feature, as it acts as the first cut-off or throttle in closing and will protect the seat and disc. Attention is also called to the fact that even if the pressure is admitted to the top of the disc, the self-cleaning feature is just as effective, which is a very decided advantage over any valve known.

These valves are designed for the highest boiler pressures, and, owing to their correct mechanical construction, have proved very successful. They are manufactured by the Golden-Anderson Specialty Company, Pittsburg, Pa.

SELECTED BOILER PATENTS.

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

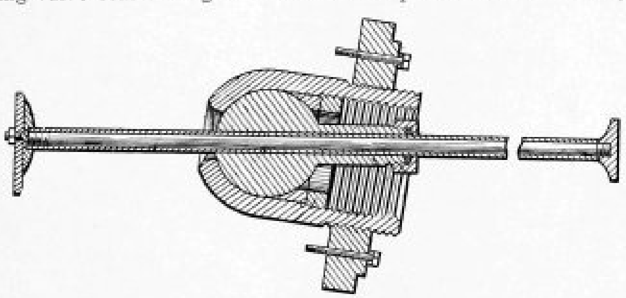
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

828,414. FEED-WATER HEATER. Henry W. Legel, Kansas City, Mo.

Claim.—A feed-water heater, comprising a casing, a partition dividing the same into an upper and a lower compartment, a water-supply pipe communicating with the upper end of the upper compartment, means for withdrawing the water from the bottom of the upper compartment, a pipe communicating with and projecting upward a suitable distance into the upper compartment, a steam-exhaust pipe communicating with the upper end of the upper compartment, an exit water pipe communicating with the upper compartment below the discharge end of the pipe projecting upwardly therein, one or more superposed pans in the casing between the pipes for supplying water and exhausting the steam and the pipes for supplying the steam and withdrawing the water, a float-casing communicating with the upper compartment of the first-named casing below the discharge end of the pipe projecting upwardly therein, a float in the float-casing, a valve controlling the water-supply pipe, and connections whereby the rising of the float a predetermined distance shall close said valve. Three claims.

829,024. BOILER SCRAPER. Frank Ludwig, Montrose, Col.

Claim.—In a boiler cleaner or scraper, the combination of a hand-plate adapted to be secured in the handhole of a boiler, a valve-seat in said hand-plate, a ball-valve within said valve-seat, a rod adapted to operate through said ball-valve, a locking-valve seat through which said rod passes into the boiler,



the opening within said valve-seat being of a size to allow the said rod a free vertical or lateral movement, means for scraping the boiler secured to the inner end of said rod and a valve behind said scraping means adapted to be seated on said locking-valve seat to hold said rod in a central position within said hand-plate when the device is not in use. One claim.

828,498. AIR-FEEDING DEVICE FOR STEAM GENERATORS. Charles D. Mosher, New York.

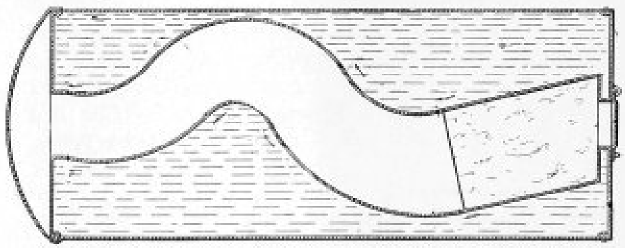
Claim.—In a steam generator, a steam and a water drum parallel with each other, and connected by a plurality of generating tubes, a plurality of air-inlet tubes parallel with and directly above said generating tubes, an ash-pit, an air-channel around the water drum communicating with the air-inlet tubes and ash-pit, a combustion chamber having its wall provided with air-ducts which communicate with the air-channel and discharge air above the fire surface, and a stack having therein means for drawing air into the fire-box, and discharging the products of combustion. Seven claims.

828,600. WATER-TUBE BOILER. Harry Del Mar, New York.

Claim.—A boiler comprising a steam-drum, a water-drum and mud-drums, a series of opposed upper and lower headers, and a series of diagonally opposed tubes arranged to connect the upper headers with the steam-drum and water-drum and to connect the lower headers with the mud-drums and water-drum. Eight claims.

829,217. FURNACE. Edwin E. Jones, Cleveland, Okla.

Abs.—The essential object of this invention is to provide a furnace by means of which the gases of combustion will be effectually consumed. In securing this end, a flue is provided passing from or communicating with the fire-box, which flue is preferably though not necessarily a downtake-flue and which has a certain peculiar formation, causing the heavier and lighter bodies of the gases of combustion to take movement along crossing or interfering lines, thus bringing about



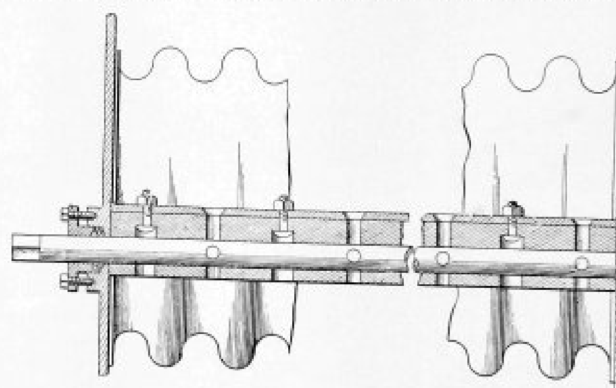
repeated intimate association between the colder and hotter gases and causing the combustible in the colder gases which would otherwise escape through the stack of the furnace to be ignited and consumed by the heat of the hotter gases. Eight claims.

829,335. STEAM AND HOT-WATER BOILER. Elbert O. Haskins, Rutherford, N. J., assignor to Abendroth Bros., Port Chester, a corporation of New York.

Claim.—In a section for a sectional boiler, a hollow narrow body between the sides arched for the fire chamber, a hollow bridge body at each side of the section and of equal width and extending over the fire chamber to divert the products of combustion around the ends, said parts contracting when the sections are set up and forming a gathering chamber over the bridge body, an uptake heating tube in said section and passage ways through the upper part of the body. Nine claims.

829,722. MARINE BOILER. George Marshall, Fremont, Neb.

Claim.—In a marine boiler, the combination of a flue or casing, a boiler shell surrounding it, a partition fitting the boiler shell and the furnace flue or casing which separates the



water in the lower portion of the boiler from that in the upper portion thereof, and which is provided with openings adapted to establish communication between the two parts of the boiler and a rod mounted to turn in the partition and having openings adapted to register with the openings in the partition. Four claims.

832,627. SUPERHEATER. Wilhelm Schmidt, Wilhelmshohe, Near Cassel, Germany.

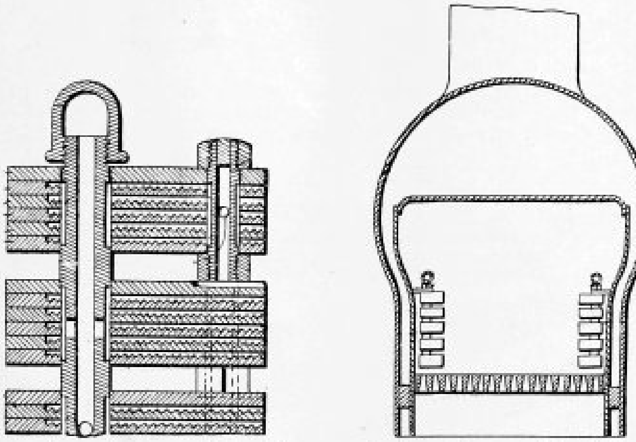
Claim.—In a steam boiler, the combination of flue tubes, superheating tubes therein, a steam chest communicating with the ends of the superheating tubes by inlet and outlet openings, and an attachment device for securing the superheating tubes to the steam chest, said device being placed between the inlet and outlet ends of said tubes, and consisting of a screw-bolt the head of which is slid into a slot at the under side of the steam chest. Three claims.

830,705. FURNACE GRATE. John Ferguson, of Hoboken, N. J.

Claim.—In a grate, a frame, a cradle journaled in the frame, rocker-bars, carried by the cradle, said rocker-bars having journal portions in alternating planes, webs connecting said portions, the journal portions being provided at their ends with inwardly extending lugs, and a plurality of grate-bars, said bars resting in the journal portions of the rocker-bars, and engaged by the said lugs. Five claims.

829,871. FURNACE FOR STEAM BOILERS. John Livingstone, Montreal, Canada.

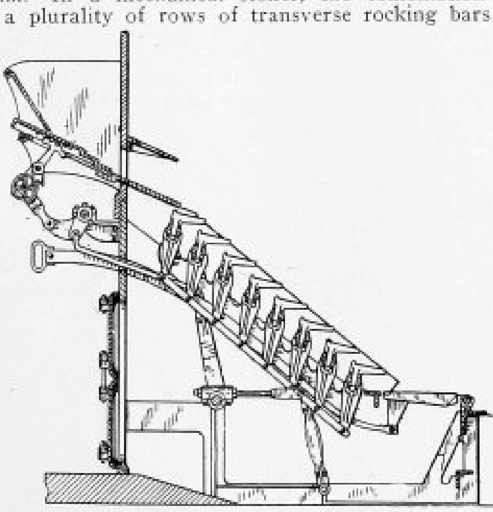
Claim.—A steam boiler furnace having a fire-box provided with steam superheaters arranged on each side of the fire-box, but set a little distance away from the walls of the fire-box, said superheaters being formed of parallel plates connected together in groups with air spaces between the groups open-



ing into the space behind the superheaters, the parallel plates of each group being formed with shallow steam spaces between them extending out to one side and opening into the fire-box and closed on the other side, and one or more steam connector pipes extending through said plates and opening into said shallow spaces.—Thirteen claims.

829,921. FURNACE GRATE. George S. Huff and Jake J. Huff, Indianapolis, Ind., assignors to Huff Smoke Consumer & Stoker Company, Indianapolis, a corporation of Indiana.

Claim.—In a mechanical stoker, the combination of side bars, a plurality of rows of transverse rocking bars carried



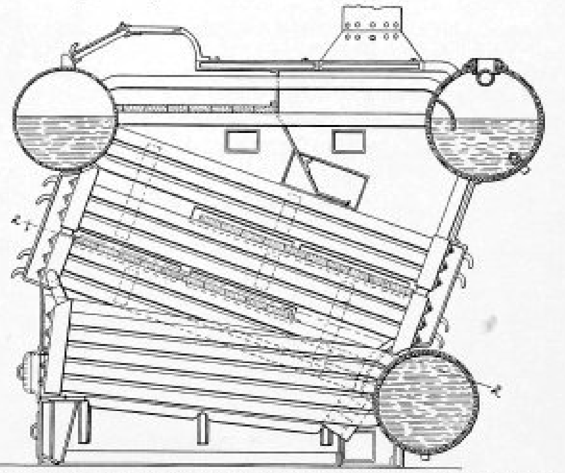
thereby, grate bars on said transverse bars, and means for imparting to said side bars a to-and-fro motion through an arc and simultaneously therewith a rocking motion to said grate bars, said means being adapted to sustain said side bars at a substantially constant angle with respect to the horizon. Thirteen claims.

834,734. FIRE-BRIDGE SMOKE CONSUMER AND FUEL ECONOMIZER. Clifford J. Johnson, Point Chevalier, and James Carlaw, Auckland, New Zealand.

Claim.—In a steam boiler furnace, a fire-bridge positioned at the rear of the fire-box and extending to the crown of the furnace and having a projection extended within the combustion chamber of the furnace, said bridge provided with a passage extending through said projection and arranged at a point above the fire-bars of the furnace, said passage opening into said combustion chamber, and a bearer situated below the bridge and having a passage arranged at a point below the fire-bars of the furnace and opening into the combustion chamber. One claim.

832,000. STEAM BOILER. Clarence H. Smith, Falmouth, Mass., assignor to Power Development Company, of Portland, a corporation of Maine.

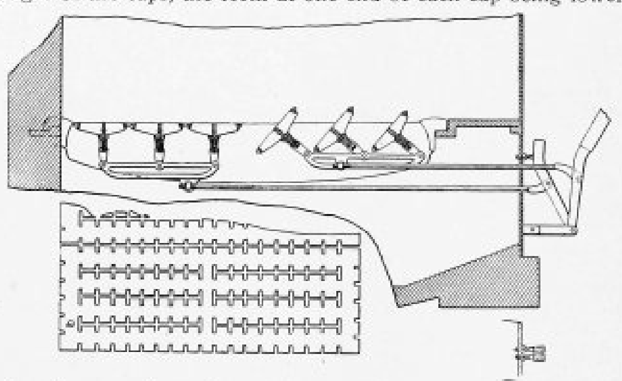
Claim.—A water-tube boiler comprising upper front and rear drums, tubes connecting said drums, a header below the rear drum and connected therewith, inclined tubes connecting said header with the front drum, a rear lower drum, headers connected respectively with the front upper drum and with



the rear lower drum, the rear header of said pair communicating with the first-mentioned header, tubes connecting said pair of headers, inclined tubes extending forward from the lower drum, a front header in which said latter tubes are connected, and a connection between the front headers. Six claims.

831,178. GRATE. William McClave, Scranton, assignor to McClave-Brooks Company, a corporation of Pennsylvania.

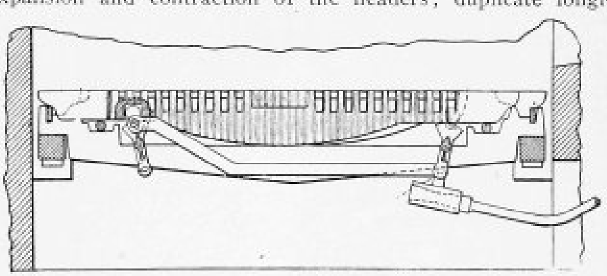
Claim.—A grate mechanism, comprising rocking grate-bars, having fuel-supporting caps, inclined teeth projecting from the edges of the caps, the teeth at one end of each cap being lower



than those at the other end, to permit of the lapping of the teeth of adjacent bars and means controlling the extent of movement of the bars, to preserve a space between the said lapping teeth. Sixteen claims.

831,342. GRATE. Frank C. Heath, Revere, Mass.

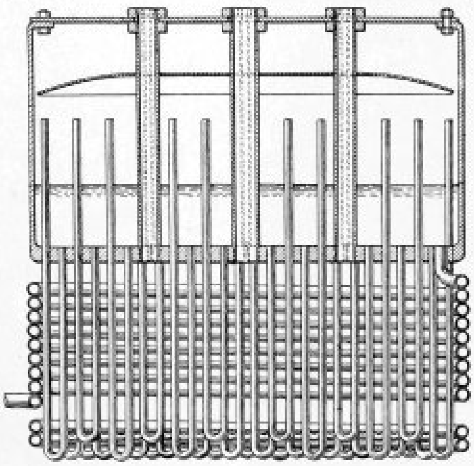
Claim.—A shaking grate comprising a header-bar at each end; the headers being duplicates and each being formed of a vertically-corrugated web and transverse fuel-holding fingers entirely separate from each other, the spaces between the fingers and the corrugated webs permitting free longitudinal expansion and contraction of the headers; duplicate longi-



tudinal grate bars having lateral fuel-supporting fingers in the same plane with each other and with the surfaces of the headers and longitudinal fingers at their ends projecting between the fingers of the headers; and duplicate rockers and rollers supporting the longitudinal bars adjacent their ends, the bars having longitudinal ribs vertically corrugated to permit elongation and contraction without fracture thereof, and the rollers permitting such elongation and contraction to take place freely. Ten claims.

831,124. STEAM GENERATOR. George A. Walton, of New York, N. Y.

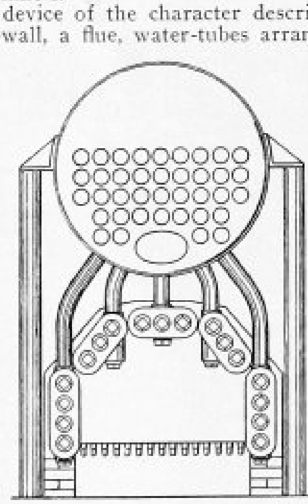
Claim.—A steam generator comprising a boiler, a casing about the boiler at a distance therefrom to provide a flue between the boiler and casing, generator elements depending



from the boiler, a preheating coil in the casing having its convolutions substantially contiguous and surrounding the generator elements and arranged to provide a passage between its upper portion and the boiler, and a superheating coil also surrounding the generator elements. Five claims.

830,129. BOILER. William W. Bonson, Dubuque, Ia., assignor to Bonson Furnace & Boiler Company, of Chicago, a corporation of Illinois.

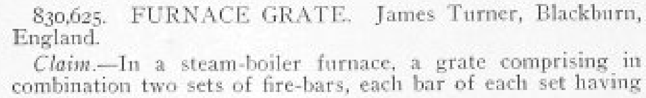
Claim. In a device of the character described, a boiler, a grate, a bridge-wall, a flue, water-tubes arranged in sections



over the furnace, means disposed along said water-tubes for protecting the boiler from the direct heat of the furnace and forming a fire communication with the first-mentioned flue, a water-tube connecting each section of the water-tubes in the furnace with the boiler at the front, a rear water-leg in the rear, and water communication between the water-tubes in the furnace and the boiler through the rear water-leg. Ten claims.

830,625. FURNACE GRATE. James Turner, Blackburn, England.

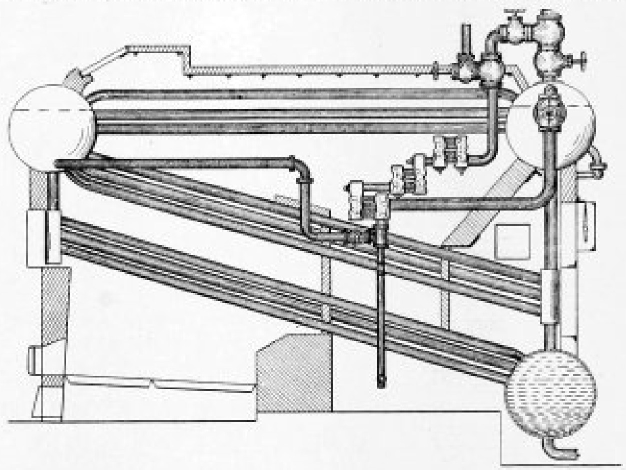
Claim.—In a steam-boiler furnace, a grate comprising in combination two sets of fire-bars, each bar of each set having



a series of transverse elongated slits in its web with the major axis of each slot at an angle of about 45 degrees with the upper face of the bar, and each bar also having a series of inclined grooves in each face of its web opening into the slots at one end and on the top edge of the bar at the other end, and a bearer for supporting the adjoining ends of the two sets of fire-bars, said bearer being of T cross-section and having longitudinal openings in the vertical and horizontal parts, the openings in the said horizontal parts being adapted to supply air between the two sets of fire-bars. One claim.

831,999. SUPER-HEATER. Clarence H. Smith, Falmouth, Mass., assignor to Power Development Company, Portland, a corporation of Maine

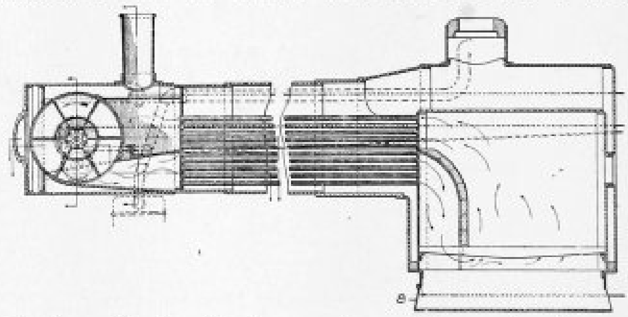
Claim.—The combination with a steam boiler having upper front and rear drums and water-circulating tubes connecting said drums, of a super-heater comprising a series of tubes ex-



tending transversely of the boiler below said water-circulating tubes, headers in which the ends of said tubes are connected, a steam pipe connecting the steam space of the rear drum with one of said headers and connections between the other of said headers and the steam-delivery main. Six claims.

833,008. MECHANICAL DRAFT AND MIXING APPARATUS FOR FLUE BOILERS. Cyrus Smith, Irwin, Pa.

Claim.—In a device of the character specified, the combination with a furnace, of a series of horizontally arranged fire flues leading therefrom, a portion of said fire flues communicating with the furnace underneath the fire, a shell



inclosing all of said flues and providing a chamber at the outer ends thereof, a normally open stack communicating with said chamber, and a fan located in said chamber and having its inlet communicating with said chamber and its outlet communicating with the flues leading underneath the fire. Nine claims.

832,760. BOILER CLEANER. Calvin F. Tucker, Carterville, Mo.

Abs.—The invention resides in a guard or shield having an opening in one end thereof to permit the passage of steam and water between the shield and the bottom of the boiler when the blow-off cock is opened and the shield adjusted to operable position. Six claims.

832,735. STEAMWAY FOR LOCOMOTIVES. William T. L. Jones and Julian C. Faidley, Clifton Forge, Va.

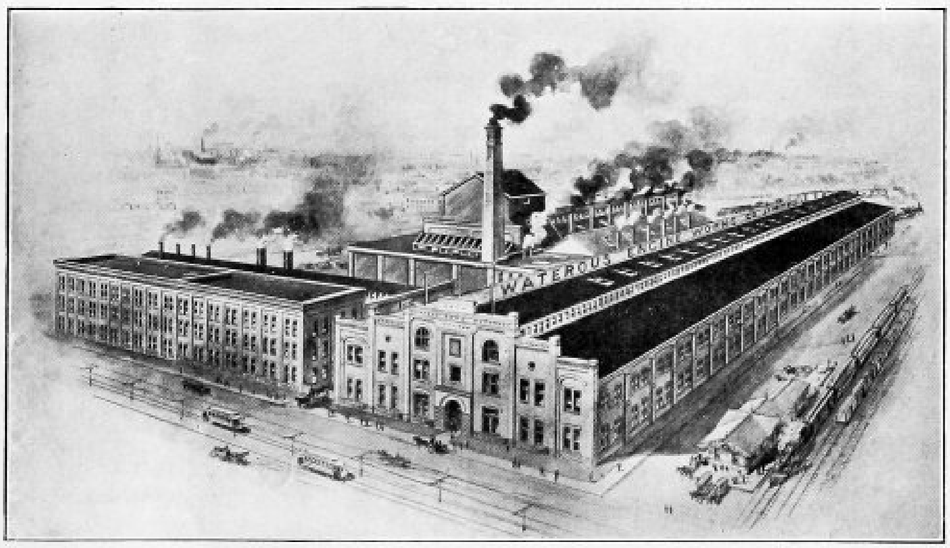
Claim.—The combination with a locomotive boiler, of a trough-like member secured to the inside of the top of the boiler shell, means for conducting steam from the steam dome into said trough-like member and means for conducting steam from the forward end of said trough-like member to the steam chests of the locomotive. Nine claims.

THE BOILER MAKER

VOL. VII FEBRUARY, 1907 No. 2

THE BOILER PLANT OF THE WATEROUS ENGINE WORKS COMPANY

Situated 76 miles west of Buffalo, on the main lines of the Grand Trunk and T. H. & B. Railways, which give connection with the Canadian Pacific and Michigan Central, is the important industrial city of Brantford, Canada. In this city in the early '40s originated the Waterous Engine Works Company. In addition to being the pioneer engine works of Canada, the company has grown gradually to be one of the largest in that country. Sixty years of successful business have earned for them the just reputation for the various line they manufacture, consisting of all types of engines, boilers, sawmills, elevators and pulp-mill machinery. The Waterous fire engines and road rollers, which are made in several sizes, have long been known as examples of the high-class work turned out by this company. Recently a plowing engine has also been placed on the market by them which has proved very satisfactory.



THE WATEROUS ENGINE WORKS COMPANY.

Several views of the boiler shop are herewith shown. This shop is 80 feet by 220 feet with annexes. Additions to the present equipment are now being contemplated. The main span of shop is traversed by a 20-ton electric crane. There are numerous jib cranes and air hoists throughout the shop. The equipment of this department consists of the following:

One Wood 130-ton sectional flanger.
One Wood hydraulic riveter.
One set of 14-foot rolls, especially for main work.
Two small rolls for sheet-iron work.
One 48-inch (throat) vertical punch.
One 30-inch (throat) double punch and shears.
One horizontal punch.
One planer.
One small drill.
One radial drill.
One annealing furnace.

The president and general manager of this company is Mr. C. H. Waterous.

Mr. Charles Wolfe, the general superintendent of the plant, has been in their service nearly two score of years and was for twenty-five years foreman of the boiler department, having been promoted to his present position through meritorious services.

Mr. H. S. Jeffery, now head of the boiler department, has been associated with the company since last June. To the readers of The Boiler Maker he needs no introduction, having contributed many articles for our columns.

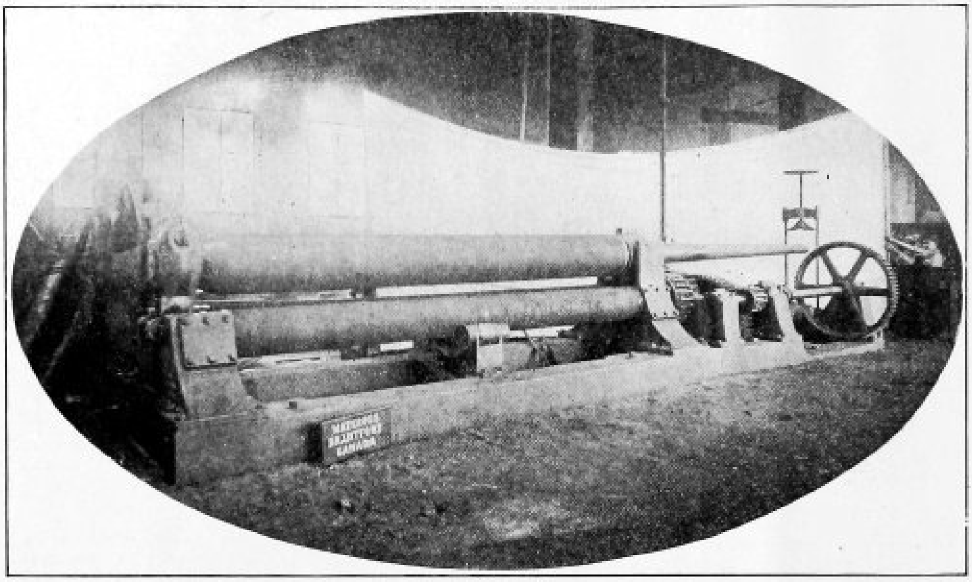
Mr. William Syrie, foreman of the boiler department, has been connected with the company for the last twenty-six years, having served his apprenticeship with this firm. The great variety of new and repair work which they have accomplished has given to Mr. Syrie a good opportunity to thoroughly understand boiler and sheet-iron work in all its branches. He has readily taken advantage of all these opportunities and to-day is well qualified for his responsible position.

The firm has now on hand a large number of orders, with the prospect that next year's work will be the greatest in their history. They enjoy, in addition to their home trade, a large foreign business.

A Description of the Manufacture of Seamless Steel Boiler Tubes.

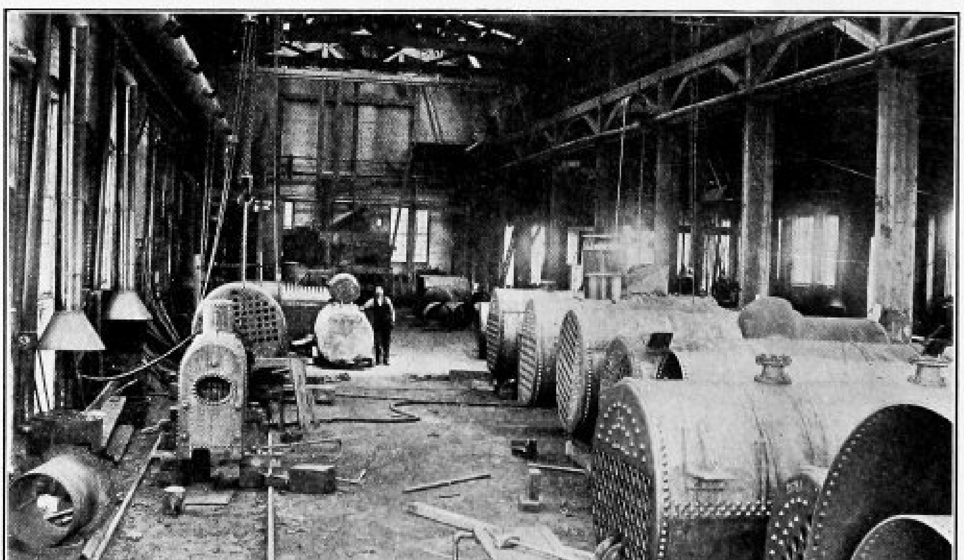
BY C. A. M'ALLISTER, ENGINEER IN CHIEF, U. S. R. C. S.

Since the introduction of the tubular boiler the subject of tubes has been one of vital importance to the marine engineer, and the advent of the water-tube boiler for use on shipboard has increased this importance. Welded iron tubes were almost universally used in the earlier days, but the employment of higher steam pressures created a demand for a superior metal for this purpose. Consequently, in the early nineties the prevailing practice of the Navy, and of the merchant service to a large extent, was to use lap-welded steel tubes. The experience with this material proved somewhat disastrous, for, in order to obtain a grade of steel which could be successfully welded, manufacturers were compelled to use billets, which were taken from the tops of ingots as cast, to get material of sufficient porosity to weld properly. However, the welded steel tube era in boiler construction was of but short duration for marine purposes. It was found that steel of the right grade for welding was easily pitted and corroded when put in use. Indeed, so rapidly did this pitting and corrosion take place that, in one instance at least (that of the cruiser *Detroit*), every boiler had to be retubed after less than six months of service. A few experiences similar to the one quoted caused a quick return to charcoal iron tubes.



14-FOOT ROLLS, WATEROUS ENGINE WORKS COMPANY.

About this time seamless drawn steel tubes began to attract the attention of designers of marine boilers. They had been used successfully in some small tubular boilers, but had not been used for Scotch boilers. The naval authorities, foreseeing the advantages of this type of tube, began to investigate the matter, and, with this as an incentive, American manufacturers put forth their best efforts to produce tubes of such diameters and qualities as to fulfill the Navy requirements. The results have been highly satisfactory, both to manufacturer and consumer, as to-day all tubes used in the con-



LOOKING WEST IN THE SOUTH BAY OF THE BOILER SHOP, WATEROUS ENGINE WORKS COMPANY.

struction of boilers for the Navy, whether of the fire-tube or water-tube type, are of seamless drawn steel. The large orders of these tubes incident to their adoption for naval purposes have enabled manufacturers to produce and sell seamless steel tubes. The merchant service, also, is making extensive use of the seamless tubes.

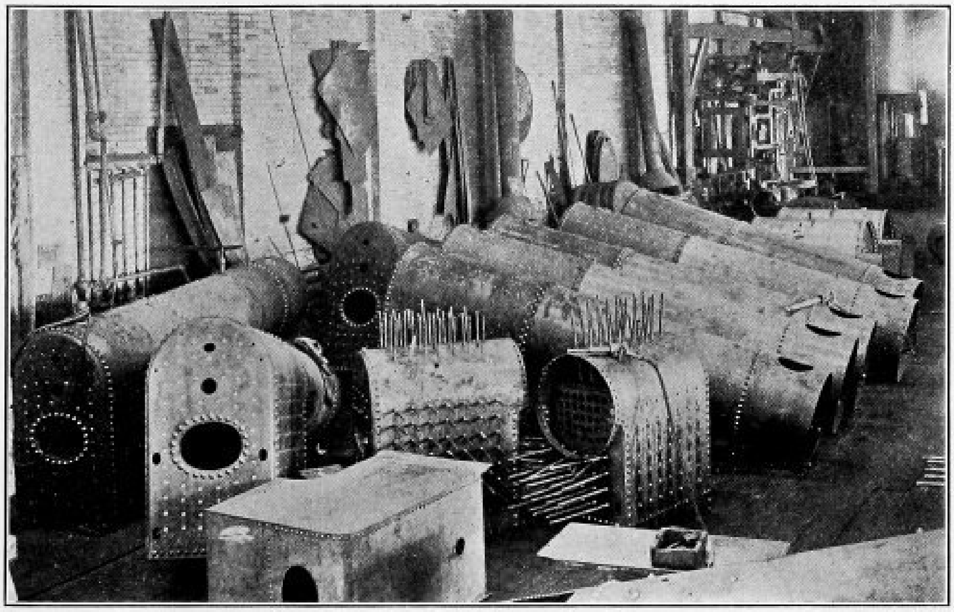
As comparatively little has been written concerning the method of manufacturing this product, the following brief description may be of interest. As the ends of nearly all tubes must be either beaded over or expanded, a soft grade of low carbon steel is required in the manufacture. The steel best suited for this purpose is that taken from the bottom half of the ingot, and showing a chemical constituency approximately as follows: Carbon, 0.17 percent; manganese, .45; sulphur not exceeding .023, and phosphorous not exceeding .01 percent. When made from steel of this analysis, samples cut from the finished tubes show a tensile strength of between 48,000 and 56,000 pounds per square inch, and an elongation in a length of 8 inches varying from 25 to 30 percent.

The steel used in most of the tube mills is made by the basic open hearth process, and is received from the steel mills in round billets 4 inches in diameter and from 8 to 10 feet in length. The first step in the manufacture is to heat the billets to a cherry red, and to "hot saw" them into such lengths as will provide sufficient material for the size of tubes ordered.

These short billets are then heated to a white heat, and taken to the piercing mill. In this mill they are revolved rapidly and driven up against the piercer, which also revolves, but at a slower rate of speed. A longitudinal hole about 1 inch diameter is thus pierced through the center of the billet. This process can be performed successfully on billets as long as 12 or 15 feet, but the ordinary lengths are from 2 to 5 feet. At the same heat the billet is next run over an expander, which increases the diameter of the hole to a size suitable for the rolling process. After being thus pierced and expanded, the pieces are known as "hollow billets," and are ready for the hot rolling process. In the newer mills the billets are taken to the rolls before cooling off. The rolls are similar to the ordinary rolls used in making rods, but tubes must be rolled in only one direction, and then passed back over the top of the rolls, as they are run over a mandrel, which insures a cylindrical inner surface. They are usually given from twelve to fourteen passes through the rolls, which process reduces them to a diameter about ½ inch larger than the finished tube is required to be and from four to six gages (B. W. G.) thicker. At each pass through the rolls, the operators give the hot tube a quarter of a turn, so that all parts may receive an equal amount of working.

After going through the rolls, one end of each tube is crushed down on all sides, or "pointed," to insure a solid grip for the pliers or tongs on the cold drawing benches.

Having been heated to a white heat, these tubes are covered with a heavy mill scale, which, if not removed, would cause considerable trouble and produce rough surfaces on the tubes when cold drawn. Therefore, before cold drawing, they are immersed in a warm bath of dilute sulphuric acid, which, to a considerable extent, removes the objectionable scale. To provide for the proper lubrication of the surfaces when the tube is drawn through the dies, the pickling is followed by an immersion in a mixture of tallow and flour dissolved in warm water. This process is known in the mill vernacular as "doping." The tubes are placed in an oven where the "dope" is dried on, and a complete and uniform distribution of this lubricant thus insured. They are then ready for the cold drawing bench, which consists of a horizontal framework about 2 feet in height, upon which is a rigid support for the dies. The power for the drawing is furnished through an endless chain, constructed of flat links three or four links in width. This chain is kept in constant motion at a uniform rate of speed. The pointed end of this tube is run through the die, and at the same time the mandrel on the end of a long rod is run through the tube, so that it comes directly inside the die. The end of the rod is fastened to a rigid support on the outer end of the bench, thus holding the mandrel in the right position relative to the die during the drawing. The pliers, or gripping tongs, are then fastened to the pointed end of the tube, and the hooks on the pliers are dropped into the spaces between the links of the endless chain. The tube is thus slowly drawn through the die and over the mandrel, gradually increasing in length and decreasing in diameter and thickness. This process is repeated five or six times, until the tube is reduced to the required diameter and thickness.



VIEW IN THE SOUTH BAY OF THE BOILER SHOP, WATEROUS ENGINE WORKS COMPANY.

The tubes are annealed after each of these cold passes, and again put through the pickling and doping processes, except at the finishing pass, when they are immersed in oil, instead of "dope," which gives them a bright, silvery surface. The object of annealing the tubes after each cold pass is to remove the local strains incident to the drawing. If, during any of these cold passes, the slightest scratch or other defect develops in either the die or mandrel, the surfaces of the tubes will be seamed or scratched throughout their entire length. It is, therefore, essential that the dies and mandrels be given a careful inspection after each pass, so that any defect may be remedied. As the men in the bench room are paid on the tonnage system, or in proportion to the output, they naturally grow careless in watching the dies, but if the proper attention is given, tubes can be produced absolutely smooth on both surfaces. Should such defects as snakes, seams or laps exist in the billet, they will almost invariably show in the finished tube, and great care must be taken in examining the tubes before the final annealing. The usual practice of the inspector is to rub over the entire length of each tube with a piece of waste, the existence of a sliver, lap or tear being then easily detected by the lodging of pieces of waste at the defective parts. Scratches on the inside are discovered by running the finger nail around the inner circumference, and if any scratches are deep enough to catch the nail, the tube should be rejected.

After the tubes have passed the surface inspection, they are cut off in a lathe to the lengths required, and gaged with a micrometer. They are generally found to be quite uniform in thickness, but frequently one is discovered to be eccentric, or below gage, and is therefore rejected. The requisite number of test pieces are cut off from the ends of tubes selected at random, usually to represent lots of 100 tubes each, and these pieces are annealed in the same charge with the tubes which they represent. After being annealed, every tube is subjected to an internal hydrostatic pressure of from 1,200 to 1,500 pounds per square inch, whether required by specifications or not, thus insuring perfect tubes, so far as strength is concerned.

The following are the requirements for all seamless cold-drawn steel tubes furnished to the Government:

Tests for Seamless Cold Drawn Steel Boiler Tubes.

1. These tubes shall be made of low carbon mild steel, of the best composition for the purpose, and uniform in quality and grade.

2. The tubes will be inspected for surface defects after being straightened, but before being cut to length, and they must be free from rust, scale, sand marks, laminations, hard spots, checks, cracks, and injurious defects generally.

3. The pointed end of the tubes will then be cut off, trimmed and gaged, and each tube at the thinnest point must be up to the gage ordered. The interior of each tube will be inspected at the same time, and any that are badly seamed or scratched in the drawing will be rejected.

4. The tubes which have passed the above inspection will then be cut to the lengths ordered and gaged at the end last cut off, and each tube at the thinnest point must be up to the gage ordered. A sufficient number of these tubes, selected and stamped by the engineer inspector, will be cut about 4 inches longer than ordered.

5. If the tube ends are flanged, swaged down, swelled, upset, or reinforced, they will be inspected afterwards to see that no material damage has been done by this process.

6. Each tube shall be subjected to 1,000 pounds internal hydrostatic pressure without showing weakness or defects.

7. All tubes must be annealed in retorts or an approved furnace in which the flame from the fuel used in heating the annealing furnaces does not strike the tubes. One or more of the stamped test tubes will be placed in the center of each retort or middle of each furnace charge, one for each twenty-five tubes or less. The charge of each retort or furnace will be numbered and kept separate until the tests are completed. The test tubes will be given the same number as the charge with which they are annealed, so that if it is found after testing that any lot is not soft enough, it may be reannealed.

8. The annealed tubes will then be divided into lots of not more than one hundred each, and the engineer inspector will subject four of the stamped test tubes belonging to each lot to the following tests:

(a) The end of one test tube must stand being flattened by hammering until the sides are brought parallel with a curve on the inside at the ends not greater in diameter than twice the thickness of the metal in the tube without showing cracks or flaws.

(b) One test tube shall have a piece one (1) inch long cut from the end, which must stand crushing in the direction of its axis under a hammer until shortened to one-half (½) inch without showing cracks or flaws.

(c) The end of one test tube, cold, shall have a smooth taper pin, taper one and one-half (1½) inches to the foot, driven into it until the end of the piece stretches one and one-eighth (1⅛) times the original diameter without showing cracks or flaws.

(d) The end of one test tube, heated to a bright cherry red, in daylight, shall have a smooth taper pin, taper one and one-half (1½) inches to the foot, at a dull red heat, in daylight, driven into it until it stretches to one and one-eighth (1⅛) times its original diameter.

If any one of those tubes selected for test fails, that tube will be rejected, and the inspector will select two extra tubes from the same lot and put them through the same test as the tube that failed, and both of these tubes must be found satisfactory in order that the lot may be passed. The failure to pass satisfactorily any one of the tests marked (a), (b), (c), (d) will reject the lot.

9. The failure of a large proportion of the tubes selected to stand any of the above specified tests in a satisfactory manner will render the whole delivery liable to rejection.

10. All tubes rejected will be marked in such a manner as to prevent their being presented a second time for inspection.

11. Each tube shall be stenciled with the name of the vessel for which intended, with the word "Seamless," and the maker's name, also with the inspector's identification stamp.

Tubes which fulfill the above requirements can be relied upon absolutely for all service put upon them in marine boilers. As to the endurance of this type of tube, it has hardly been used in marine boilers for a sufficient time to form an estimate of its longevity. The writer has, however, seen samples cut from the boiler of a locomotive, which, although covered with scales due to the minerals in the feed water, still maintained under the scale the hard, shiny surface put upon it at the tube mill. It would thus appear that the ideal boiler tube has been obtained, although it would seem that for marine purposes 5 percent nickel steel might be an improvement over the carbon steel now in use, as the former is tougher and less liable to corrode.—*Marine Engineering.*

The making of seamless steel tubing is to be started in Italy. William Voysey, of Greenville, Pa., an expert in the manufacture of steel tubing, is shortly to go to Italy to install and place in operation the piercing and rolling plants for making this product. It will be his fourth trip across the Atlantic Ocean for the purpose of installing seamless steel tubing plants in Europe.

How to Lay Out a Tubular Boiler.

PART II.

BY H. S. JEFFERY.

In Part I. the treble-riveted lap joint has been worked out, and also one problem of the double-riveted lap joint for longitudinal seams. The latter has not been taken up in detail, for the reason that its use, and in fact the use of lap joints even if treble riveted, is unreliable. The usage, however, is general in order to build cheap boilers. It is impossible to get the proper pull on the rivets in lap joints; as the plates will twist and the rivets bend somewhat before shearing, subjecting the rivets to a prying off stress in addition to a shearing stress.

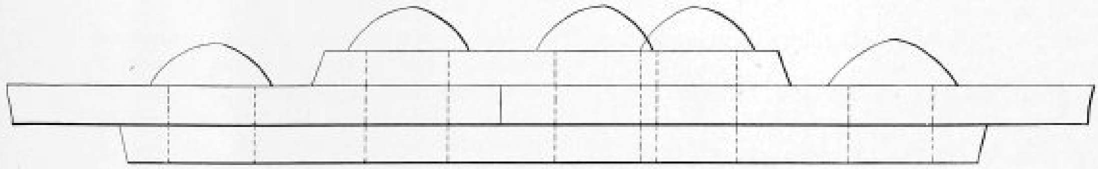
sure on head. Suppose the head is riveted to the shell with a single row of ¾-inch rivets which are 13/16 inch when driven.

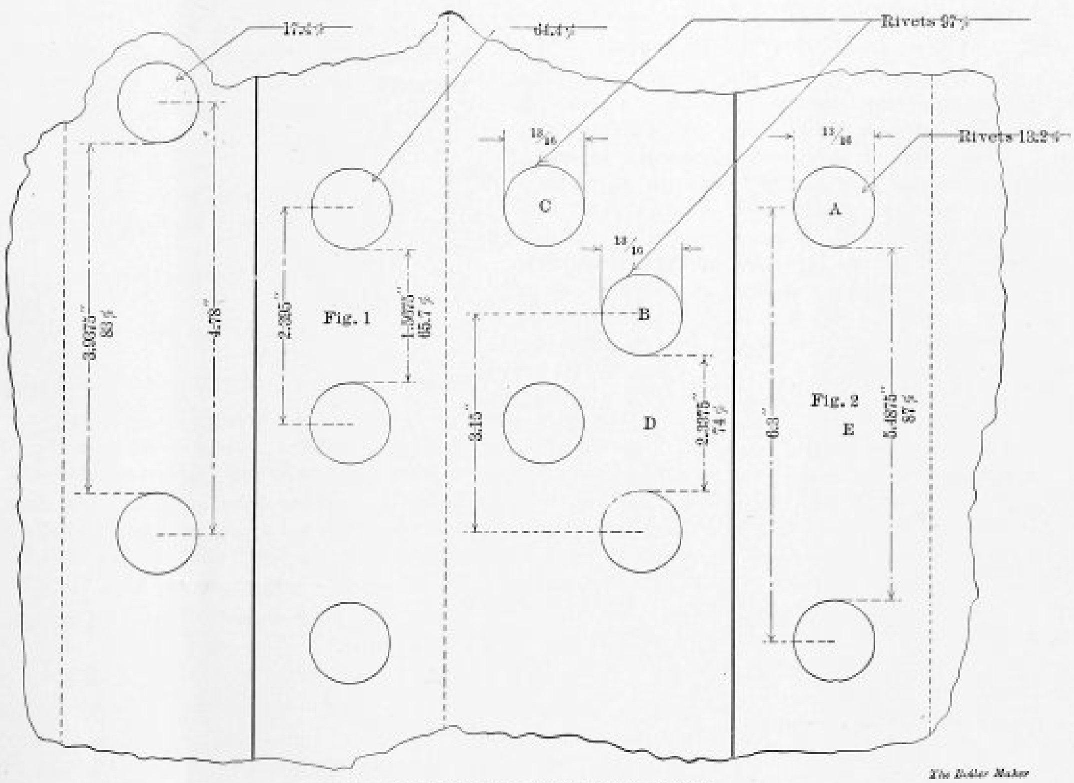
Area of 13/16 rivets = .5185 square inch. Figuring on 42,000 pounds shearing strength of rivets per square inch, we find one rivet good for:

42000 × .5185 = 21777 pounds.
487571 ÷ 21777 = 22.4 number of rivets.

Therefore, 23 rivets, 13/16 diameter, will represent the minimum number of rivets in the circumferential seams. The pitch will be determined as follows:

60 × 3.1416 = 188.5 inches, circumference.
188.5 ÷ 23 = 8.19 inches, pitch of rivets.





DOUBLE AND TREBLE RIVETED BUTT JOINTS.

The question will arise as to why the circumferential seams can go single riveted. In our boiler the flues extend from head to head, and therefore brace the greater portion of the head. Also the braces extending from shell to head help support the head. Thus the rivets are not subjected to any great strain. If it were a tank with dished heads and no flues or braces to assist the rivets, it will be seen that the stress on the rivets holding the head is not excessive. First, we must find the area of the head which will be the outside diameter of the

$$\text{head squared, times } \frac{3.1416}{4}$$

59 9/16 × 59 9/16 × .7854 = 2786.12 square inches, area.
2786.12 × 175 (pounds pressure) = 487,571 pounds, pres-

This, as will be seen, is out of all reason, or about 3½ times too great a pitch. Therefore, if we use a 2-inch pitch the rivet area creeps up more than three times. The next point is to find whether a 2-inch pitch leaves a sufficient net section of plate.

2 — 13/16 = 1 3/16 inches net section of plate.
1 3/16 × 7/16 = .5195 area of net section.
188.5 ÷ 2 = 94 spaces.
94 × .5195 = 48.833 square inches, total area of net section.
48.833 × 60,000 = 2,929,980 pounds, total strength of net section of plate.
21,777 × 94 = 2,047,038 pounds, total strength of rivets.

We find we have on the head 487,571 pounds and sufficient rivet area, providing we use a 2-inch pitch for 94 rivets, in the circumferential seam to stand 2,047,038 pounds. We find the head is subjected to 487,571 pounds pressure with net section of plate good for 2,954,796 pounds. Therefore,

2,954,796 ÷ 487,571 = 6.1 factor of safety.
2,047,038 ÷ 487,571 = 4.2 factor of safety.

These examples will throw some light on the reasons for single-riveted circumferential seams. Later on, it will be shown how the plates suffer from other causes.

If ⅞ instead of ¾ rivets were used in the circumferential seams, the area to be supported being the same, the pitch should be increased to about 2⅜ inches:

188.5 ÷ 2.375 = 79.4 number of rivets.

As a ⅞ rivet equals 15/16 when driven the corresponding area will be .69029 square inch.

42000 × .69029 = 28992.18 pounds, shearing strength of one rivet.

28992.18 × 80 = 2,319,374.4 pounds, total strength.
2319374.4 ÷ 487571 = 4.75 factor of safety.

Therefore, we gain the difference between 4.75 and 4.2, or .55; thus ⅞ rivets at this pitch give more strength than ¾ rivets at 2 inches. As the strength of the net section of plate is in excess of the strength of the rivet area, we have only to figure on the rivets in this example.

Butt Joint With Inside and Outside Straps.

Fig. 1 shows a double-riveted butt strap joint, a construction which is far superior to any lap joint. Fig. 2 shows a treble-riveted butt joint with which a very high efficiency can be obtained. Our boiler must stand 175 pounds pressure. With a treble-riveted lap joint we could not get any better than 163 pounds pressure, so that is out of consideration. Let us see if a double-riveted joint, as shown in Fig. 1, will do. We will consider that all our holes are punched small and reamed out. Thus we get a factor of safety of 4 plus ($P = 2$) or 4.20.

Having decided this, our next move is to find the efficiency of joint necessary.

Rule:

A = Radius of boiler.
B = Working pressure.
C = Constant = 100.
D = Thickness of plate in inches.
$T. S.$ = Tensile strength.
F = Factor.
E = Efficiency.

$$\frac{F \times A \times B \times C}{D \times TS} = E$$

$$\frac{4.2 \times 29.78 \times 1.75 \times 100}{.4375 \times 60000} = 83.4\%$$

We must now find out whether a double-riveted butt joint will give us 83.4 percent efficiency or not. First, we will have to ascertain the greatest pitch so we can get the strongest net section of plate, as the efficiency will be figured from the net section of plate at the outer row of rivets. This pitch wil be twice that of the inner row. In Part I we found from the table for the inner row the constant 1.75. Hence by the formula the maximum pitch will be

(7/16 × 1.75) + 1⅝ = 2.39, or about 2⅜ inches.

Therefore the pitch for the outer row will be 2⅜ × 2 = 4.75 inches.

4.75 — .9375 = 3.8125
3.8125 ÷ 4.75 = 80 percent of net section compared to solid plate.

Having taken the limit in pitch of rivets, we cannot reach the proper efficiency with a double-riveted butt joint with inside and outside straps. Hence this joint will not do for our boiler, as the following computation shows that only a pressure of 166.6 pounds per square inch would be allowed.

$$\frac{60000 \times .80 \times .875}{60 \times 4.2} = 166.6 \text{ pounds, allowable pressure.}$$

With ¾ rivets, 13/16 holes, the efficiency will be as follows:

4.75 — .8125 = 3.9375 net section of plate.
3.9375 ÷ 4.75 = 83 percent efficiency.

$$\frac{60000 \times .83 \times .875}{60 \times 4.2} = 173 \text{ pounds, allowable pressure.}$$

Here, however, another feature presents itself. The net section of plate might be strong enough, but the rivet area would very likely be too small.

Steel plate, tensile strength per square inch of section 60,000 pounds.

Thickness of plate 7/16 = .4375.
Diameter of rivet holes 13/16 = .8125.
Area of rivet hole = .5185.
Pitch of inner row = 2⅜ inches.
Pitch of outer row = 4¾ inches.
Resistance of rivets in single shear = 42000 pounds.

Resistance of rivets in double shear = 85 percent excess over single shear, or 77700 pounds.

4.75 × .4375 × 60000 = 124687.5 pounds, strength of solid plate.

4.75 ÷ .8125 = 3.9375 net section of plate.

3.9375 × .4375 × 60000 = 103359.375 pounds, strength of net section of plate.

.5185 × 2 × 77700 = 80574.9 pounds, strength of two rivets in double shear.

.5185 × 42000 = 21777 pounds, strength of one rivet in single shear.

80574.9 + 21777 = 102351.9 pounds, total strength of rivets.

Therefore the rivet strength is the weaker.

102351.9 ÷ 124687.5 = 82 percent, efficiency of rivets.
103359.375 ÷ 124687.5 = 83 percent, efficiency of plate.

Again, if ⅞ rivets were used, and the rivet efficiency increased, the efficiency of the net section of the plate would be decreased.

4.75 — .9375 = 3.7125 inches.

3.8125 × .4375 × 60000 = 100078.125 pounds, strength net section of plate.

100078.125 ÷ 124687.5 = 80 percent efficiency with ⅞ rivets.

Another rule which the author believes is quite simple is as follows:

A = Area of one rivet.
B = 1.85 constant for rivets in double shear.
B' = 1 constant for rivets in single shear.
P = Pitch for outer row of rivets.
P' = Pitch for inner row of rivets.
C = Shearing strength of rivets.
C' = Tensile strength of plate.
T = Thickness of plate in inches.
% = Percent of rivet strength compared to solid plate.
E = Number of rivets in one pitch in inner row.
E' = Number of rivets in one pitch in outer row.

$$\frac{A \times B' \times C \times E'}{P \times T \times C} + \frac{A \times B \times C \times E}{P' \times T \times C'} = \%$$

$$\frac{.5185 \times 42000 \times 1}{4.75 \times .4375 \times 60000} = 17.5 \text{ percent}$$

$$\frac{.5185 \times 1.85 \times 42000}{2.375 \times .4375 \times 60000} = 64.5 \text{ percent}$$

64.5 + 17.5 = 82 percent, efficiency of rivets.

Our readers will see that the net section of plate with 13/16 holes, 4¾-inch pitch, gives an efficiency of 83 percent, but the rivets only give 82 percent. It is necessary for the rivet percent to be in excess of the percent of the net section of plate. There are three places where the joint can fail when the rivets and the net section of the plate are nearly alike.

1. It can break through net section of plate at outer row of rivets. (This we found had an efficiency of 82 percent.)

2. It can shear the rivets (which we found had an efficiency of 82 percent).

3. It can break the net section of the plate at the inner row of rivets and shear the outer row of rivets; which are in single shear. (The following computation will show that this has an efficiency of 83 percent.)

2.375 — .8125 = 1.5625.

1.5625 ÷ 2.375 = 65.8 percent, efficiency of net section of plate at inner row.

65.8 + 17.4 = 83.2 percent.

Therefore the strength of rivets is the weaker.

Treble-Riveted Butt Joint With Inside and Outside Straps.

Let us figure the joint first with ⅞ rivets. See Part I. The constant for obtaining the pitch is 3.5 Therefore (7/16 × 3.5) + 1⅝ = 3.15 inches, maximum pitch for inner row of rivets.

3.15 × 2 = 6.30 inches, pitch for outer row.

$$\frac{A \times B' \times C \times E'}{P \times T \times C'} + \frac{A \times B \times C \times E}{P' \times T \times C'} = \%$$

$$\frac{.69 \times 1 \times 42000 \times 1}{6.30 \times .4375 \times 60000} = 17.5 \text{ percent}$$

$$\frac{.69 \times 1.85 \times 42000 \times 2}{3.15 \times .4375 \times 60000} = 130 \text{ percent}$$

130 + 17.5 = 147.5 percent, strength of rivets compared to plate.

6.30 — .9375 = 5.3625.

5.3625 ÷ 6.30 = 85 percent, efficiency of net section of plate at outer row of rivets.

3.15 — .9375 = 2.2125.

2.2125 ÷ 3.15 = 70 percent, efficiency of net section of plates at inner row of rivets.

70 + 17.5 = 87.5 percent, strength of net section of plate at inner row and shearing of outer row of rivets. Therefore, net section of plate at outer row is the weakest point.

As our rivet area is far in excess of plate, we can use a larger pitch for the rivets. By doing so we can increase the efficiency of the net section of the plate. As the pitch of rivets increases so does the net section of plate, and this increases the efficiency of plate, but the increased pitch cuts down the percentage strength of rivets.

If ¾ rivets, 13/16 holes had been used instead of ⅞ rivets, 15/16 holes, the result would have been as follows:

$$\frac{.5185 \times 1.85 \times 42000 \times 2}{3.15 \times .4375 \times 60000} = 97 \text{ percent}$$

$$\frac{.5185 \times 1 \times 42000}{6.30 \times .4375 \times 60000} = 13.2 \text{ percent}$$

97 + 13.2 = 110.2 percent, strength of rivets compared to plate. We find a large cut in rivet percentage, yet it is above the plate.

6.30 — .8125 = 5.4875.

5.4875 ÷ 6.30 = 87 percent, efficiency of net section of plate at outer row.

3.15 — .8125 = 2.3375.

2.3375 ÷ 3.15 = 74 percent, efficiency of net section of plate at inner row. To this we add the percent of rivet strength of one rivet in single shear at the outer row. Thus 74 + 13.2 = 87.2, or about 87 percent. Therefore, the breakage will occur at net section of plate at outer row of rivets as this is the weakest point.

Fig. 2 shows the layout of rivet holes when 13/16 inch in diameter.

A = Rivet in single shear with a 13.2 percent value.

B and *C* = Rivets in double shear with a 97 percent value.

A, *B* and *C* = Combined strength (13.2 + 97 percent = 110.2 percent).

E = Net section of plate at outer row with 87 percent.

D = Net section of plate at inner row with 74 percent.

A and *D* together equal 87.2 percent. It is the assistance derived from the rivet *A* that prevents *D* from being the weakest point. If the inner strap did not extend out, taking in the row of rivets *A* in single shear, the net section at *D* would be the efficiency of the joint, or 74 percent.

The following computation will show what pressure may be allowed on the boiler with this joint:

$$\frac{60000 \times .87 \times .875}{60 \times 4.2} = 181 \text{ pounds, pressure allowed with ¾-inch rivets.}$$

$$\frac{60000 \times .85 \times .875}{60 \times 4.2} = 177 \text{ pounds, allowed with ⅞-inch rivets.}$$

A Large Boiler Making Plant in the South.

Prominent among the large manufacturing concerns of the South is the Odlum-Taylor Boiler Company, of Memphis, Tenn. This concern has one of the most modern and completely equipped plate-working establishments to be found any where in the country. Their buildings are of steel and concrete-steel construction, and are 300 feet long by 158 feet wide and 53 feet high. The plant is equipped throughout with the most modern hydraulic, pneumatic, steam and electrical machinery, and the shops are situated on the main lines of the Illionois Central and Missouri Pacific Railroads, which enables them to have their raw material delivered directly in their buildings, and also permits the finished work to be loaded ready for shipment directly from the erecting floor. A 15-ton electric traveling crane aids in the handling of all material, thus saving a great labor cost.

The class of work manufactured by this company consists of boilers, smoke stacks, steel tanks, steel towers, oil-storage tanks, ice tanks, riveted pipe lines and all similar articles of sheet steel and heavy plate. One of their specialties, which is seldom manufactured by boiler concerns in the East and North, is special plate work for mining purposes, with which this company has had considerable experience and success.

The management of the plant is in the hands of men of wide experience in the manufacture of sheet steel and plate work. The officers are as follows: President, Mr. R. A. Odlum; secretary and treasurer, Mr. T. Herbert Taylor; general manager, Mr. Fred Blume.

Reports from this company indicate that a large amount of business is on hand at present and is continually handled.

A 400-ton blast furnace, together with stoves, piping, etc., for Corrigan, McKinney & Co., at Josephine, Indiana County, Pa., was constructed by the Pennsylvania Engineering Works, New Castle, Pa., in exactly eight months. This is said to break all other records for the construction of a blast furnace of this size.

Collapsing Pressures of Boiler Tubes.

The following two abstracts are taken, one from a paper by Professor Albert P. Carman, based upon a series of experiments at the Engineering Experimenting Station, University of Illinois, and the other from a paper presented by Professor Reid T. Stewart, before the American Society of Mechanical Engineers, based upon experiments made at the McKeesport works of the National Tube Company. Both series of experiments lead to practically the same results, although those of Professor Stewart were the more elaborate of the two, extending through a period of four years. The first series of experiments, which he carried out, was to determine the effect of the length of a tube upon the collapsing pressure. Professor Carman had previously made a series of tests covering this point so that he was able to work from these results. Although the experiments were not confined to boiler tubes, yet the most important application of the results is in connection with boiler tubes.

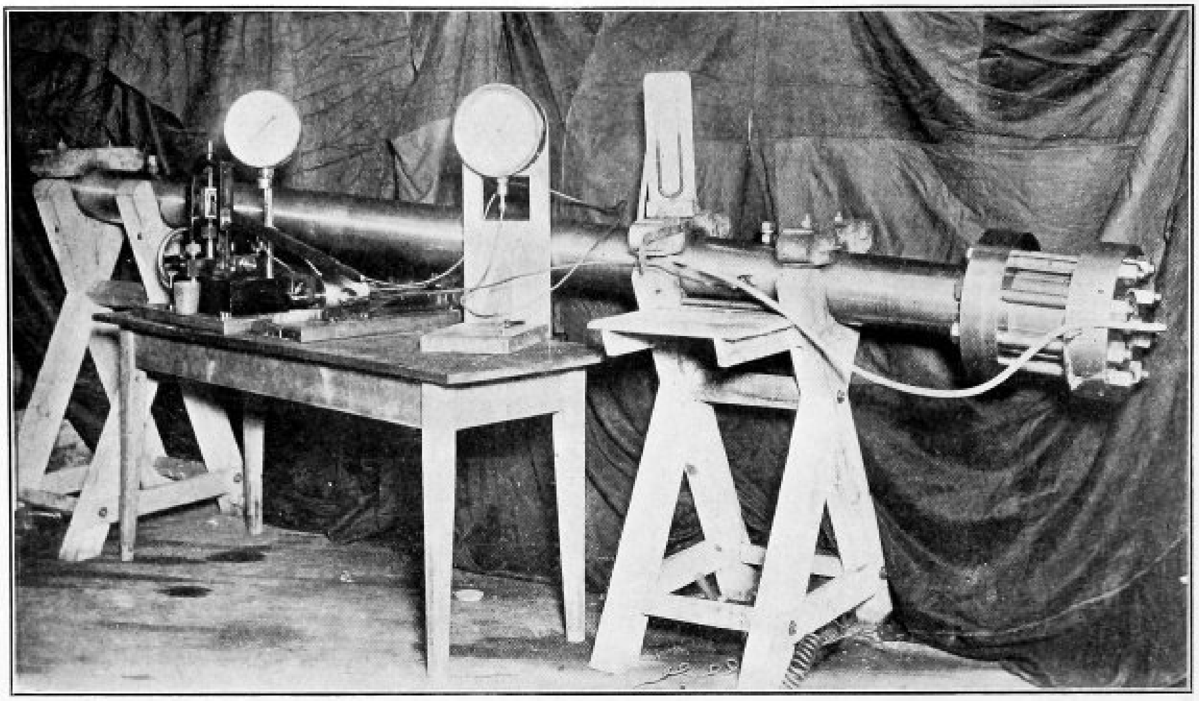


FIG. 1.—APPARATUS USED BY PROFESSOR CARMAN.

The collapsing pressure of a tube subjected to hydraulic pressure from the outside has always been an indefinite subject. All the formulae and computations of engineers involving this have hitherto been based on a brief series of tests made by Sir William Fairbairn nearly fifty years ago. Fairbairn's work was done at the suggestion and with the aid of the Royal Society and of the British Association for the Advancement of Science. The common steam pressure at that day was 50 pounds per square inch or less so only moderate pressures were used in his tests. The tubes, which he used, were made of a single thin iron plate, bent to the required form and riveted and brazed to prevent leakage into the interior. The ends of the tube to be tested were closed, and the tube was placed in a vertical position within a cast-iron cylinder and subjected to hydraulic pressure. The interior of the tube was connected to the atmosphere in order to have atmospheric pressure within the tube. The lengths of these tubes ranged from about 19 to 60 inches and all had the same thickness of wall, .043 of an inch. In all, about twenty-five satisfactory collapses were made, and from these few experiments

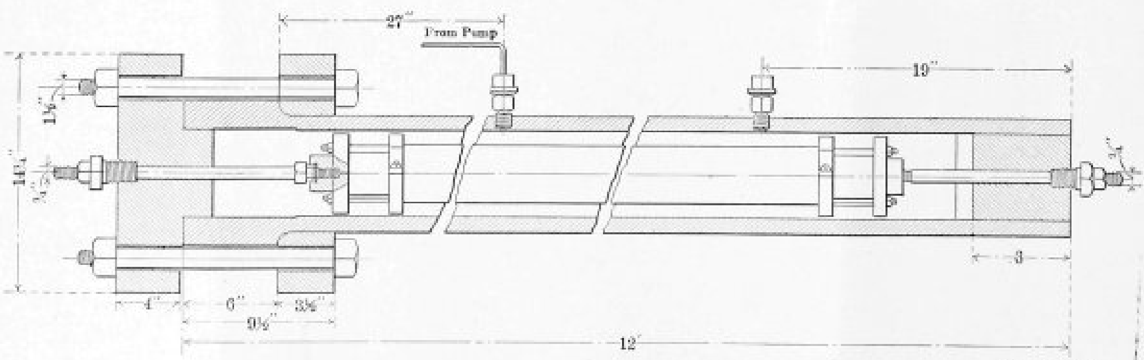


FIG. 2.—SECTION OF CYLINDER WITH TEST TUBE (PROFESSOR CARMAN'S APPARATUS.)

on short tubes, Fairbairn deduced the following formula for the collapsing pressure:

$$P = 9{,}675{,}600 \frac{T^{2.19}}{ld}$$

It will be seen that in this formula it is assumed that the collapsing pressure of a tube varies inversely as its length. Upon this formula nearly all calculations and data have been based up to this time. Recently, however, students of the theory of elasticity have attempted to derive formulae for the collapsing pressure of tubes, and have been led by their results to doubt the accuracy of Fairbairn's forumla. Numerous other formulae have been deduced, but all were merely attempts to state the results of Fairbain's experiments by a more general and convenient empirical formula.

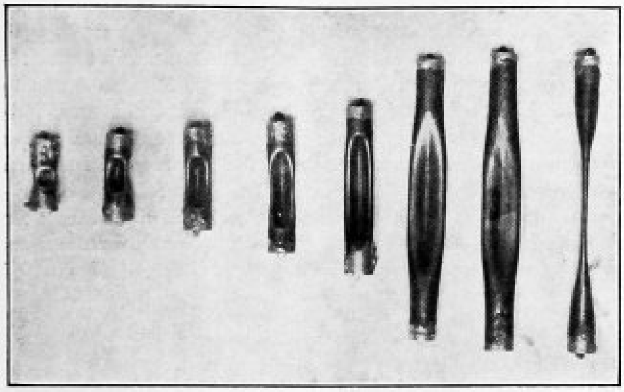


FIG. 3.—SPECIMENS OF COLLAPSED BRASS TUBES.

The first tests made by Prof. Carman were upon twenty-five small seamless brass tubes, to test the principle characteristic of the Fairbain formula, viz., that the collapsing pressure varies inversely as the length. Twenty-five of these small tubes were collapsed by hydraulic pressure. The diameter, thickness of wall, length and collapsing pressures are shown in the following table:

TABLE OF COLLAPSING PRESSURES OF SMALL SEAMLESS BRASS TUBES.

Mean Diameter, Inches.	Thickness of Wall, Inches.	Length, Inches.	Collapsing Pressure, Lb. per Sq. In.
.350	.0163	.315	4125
.350	.0163	.472	3415
.350	.0163	.709	3200
.350	.0163	1.063	2248
.350	.0163	1.570	1778
.350	.0163	3.150	1850
.350	.0163	3.540	1850
.350	.0163	1.570	9525
.441	.0315	2.280	6975
.441	.0315	2.715	6690
.441	.0315	3.345	6690
.441	.0315	3.820	6400
.441	.0315	7.480	6690
.721	.0315	1.220	7750
.721	.0315	1.733	6620
.721	.0315	2.280	6260
.721	.0315	3.030	5120
.721	.0315	8.200	4980
.721	.0315	3.420	11940
.701	.0531	3.500	12200
.701	.0531	5.120	12090
.701	.0531	5.120	12020
.701	.0531	5.190	11940
.701	.0531	5.270	12090
.701	.0531	8.270	12090

The curve, Fig. 4, shows the relation between length and collapsing pressure for tubes 0.35 of an inch in diameter. The curves for the other diameters are of the same shape. The following conclusions were drawn. "An inspection of these curves and data shows immediately that there is a minimum length for each tube beyond which the collapsing pressure is constant; and further, that this minimum length is quite definite. Again, we see that for lengths less than this critical minimum length, the collapsing pressures rise rapidly. As definitely as can be determined from these small tubes, the collapsing pressure varies inversely as the length, for lengths less than the critical length. In this they follow Fairbairn's formula, and suggest that Fairbairn's tubes were all shorter than their critical lengths."

The curves show that this critical length is about six times the diameter of the tube.

These previous experiments had thus shown the inadequacy of Fairbairn's formula, and they had particularly shown the very narrow range of the law of inverse lengths. When the present series of experiments on standard steel boiler flues was begun, little attention was therefore paid to the law of lengths, except to see that the tubes were longer than the critical minimum length.

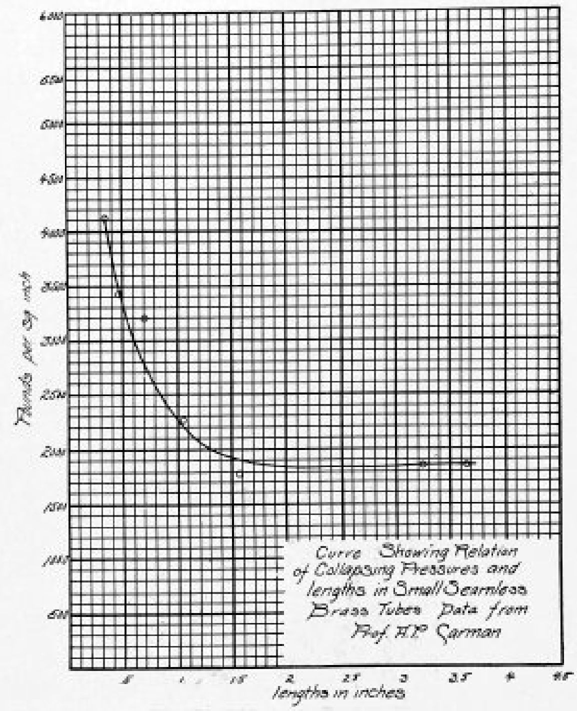


FIG. 4.

The method followed in the present tests was similar to that used by Fairbairn. The tube to be tested was closed at both ends, placed inside a stout steel cylinder, and there subjected to increasing external water pressure until the tube collapsed. The pressures were read by hydraulic gages. The cylinder used in all these experiments was a section of a nickel-steel naval gun tube, kindly furnished at a nominal price by the Bethlehem Steel Company, Bethlehem, Pa. The dimensions of this gun tube were: length, 12 feet; external diameter, 7 inches; internal diameter, 5 inches. For a distance of 6 inches at one end, the external diameter was left at 9 inches, thus making a shoulder against which the end plug could be clamped. This plug was a steel disc with a projection, and was held in place by heavy cast-iron rings and eight 1¼-inch steel bolts. A lead gasket with circular grooves in the end face of the tube

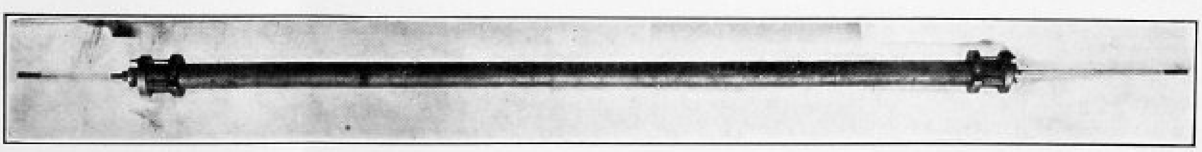


FIG. 5.—PHOTOGRAPH OF TUBE ABOUT TO BE TESTED, SHOWING MANNER OF CLOSING THE ENDS.

prevented leakage, even at the highest pressures. The other end of the nickel-steel cylinder was closed by a cast-iron plug 6 inches long, shrunk into place. A ¾-inch hole for stay rods was drilled through the center of each end plug. Leakage about the rods was prevented by packing held in place by bushing nuts. These stay rods were made of ¾-inch steel shafting, and were screwed, one into each end plug of the tube to be tested. The tube could thus be put under tension so as to take up the end pressures. One of these stay rods had a small hole through it connecting the interior of the tube with the atmosphere. By rubber tubing, the interior could be connected with a U manometer. This manometer was very useful in indicating any leakage.

The following method was used to close the ends of the tubes. Tool-steel clamps were made in the shape of split rings, hinged on one side and held together on the other side by bolts. These ring clamps were placed on the tube near the end as a grip, and slipping was prevented by burring the tube with a cold chisel. A steel disc faced with a sheet of lead was then drawn tight against the plane ends of the tube by bolts screwing into the clamps. After the ends were clamped on the tube it could be tested for leakage by placing the whole tube in a trough of water, and pumping air into it with a foot bicycle pump through the bored stay rod. It was seldom that a tube tested in this way leaked when subjected even to high external water pressure. The connections with the gages, pump and the hydrant were made through small holes bored in the nickel-steel cylinder. These holes were made tight by special screw plugs and leather gaskets. The cylinder was mounted on two heavy trestles and inclined so as to allow the easy escape of the air when filling it with water. The pressures were produced by a Cailletet pump made by the Societé Genevoise, of Geneva, Switzerland. The pump was capable of producing pressures of 1,000 kilograms per square centimeter, or approximately 14,000 pounds per square inch. Copper pressure tubing was used to connect the pump and the gages with the cylinder. Four gages made by Shæffer and Budenberg were used, viz.:

No. 1, reading to 8,000 pounds per square inch.
No. 2, reading to 14,000 pounds per square inch.
No. 3, reading to 3,000 pounds per square inch.
No. 4, reading to 4,200 pounds per square inch.

Gages Nos. 1 and 3 had maximum pointers, and all had check valves to protect the springs from the shock at collapse. The drawing of the cylinder, Fig. 2, and the photograph, Fig. 1, of the assembled apparatus show other features not easily described.

When a test was to be made, the prepared tube was placed in the cylinder, the heavy head bolted on, and the cylinder filled with water from the hydrant. All the openings were then closed, and the pressure pump started. Several minutes of pumping were usually required before the gages began to record. Except for a few thin tubes of large diameter, failure, which was sudden in all cases, was accompanied by a sound much like that accompanying the failure of a specimen in a testing machine. Failure was also indicated by the dropping of the gages and the rise of the water in the manometer connected with the inside of the tube. Each specimen was carefully measured after collapse, and in the case of most of the tested tubes, the collapsed portion was sawed across and the actual average thickness of the tube was obtained. Nearly all of the tubes tested were 10 feet long at the start. In many cases, three or more collapses were made by cutting off the collapsed portion after each failure and then testing the remainder of the tube. The tubes tested were commercial steel boiler tubes, both lap-welded and cold drawn seamless. Some of the tubes used were given by J. T. Ryerson & Son, Chicago, and the Scully Steel & Iron Company, Chicago, while the remainder were bought in the open market.

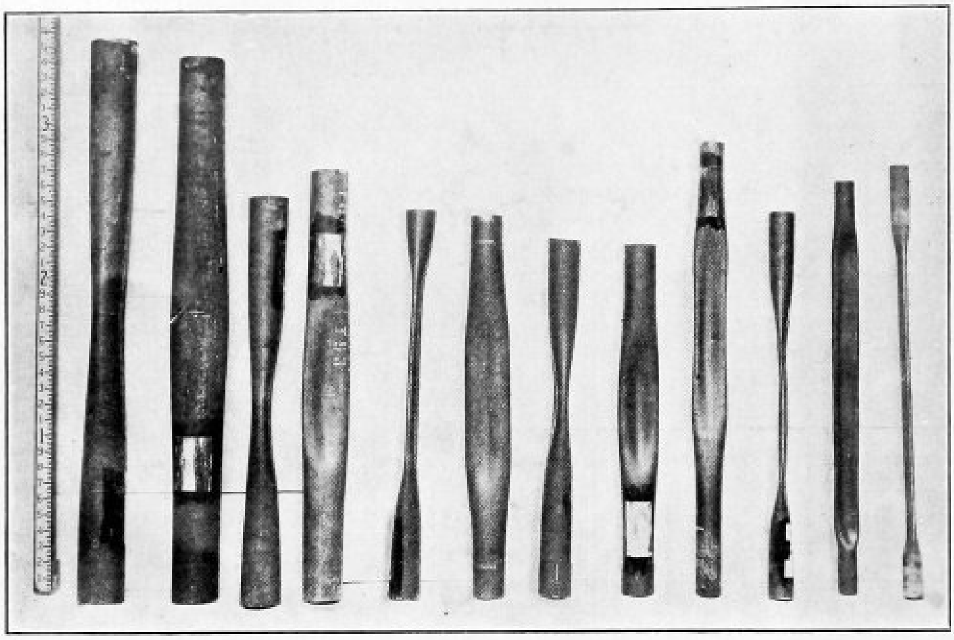


FIG. 6.—SPECIMENS OF TUBES SHOWING THE NATURE OF COLLAPSE.

CHEMICAL TESTS OF SAMPLES OF BOILER FLUES COLLAPSED.

Description of Sample of Flue.	Chemical Analysis.				
	Si	S	P	Mn	C
Lap-welded steel	....	.021	.137	.286	.080
Lap-welded steel	....	.038	.099	.330	.080
Seamless cold drawn steel	....	.001	.018	.462	.170
Seamless cold drawn steel	....	.002	.013	.525	.220

Tests were also made upon a set of brass tubes similar in size to the steel tubes. The advantage of the brass tube tests was that the dimensions and the material were much more uniform.

It is impossible to give here the data taken by Prof. Carman, but the following conclusions and formulæ were derived from it by him:

All considerations show that the collapsing pressure of a tube is a function of t, the thickness of the tube wall, and also of d, the diameter, varying directly as some function of t, and inversely as some function of d. Further, all the theoretical discussions indicate that this collapsing pressure varies as a function of the ratio $\frac{t}{d}$, *i. e.*, that t and d have the same exponents. The simplest method of showing and studying the relation between p, the collapsing pressure, and the ratio $\frac{t}{d}$ is the graphic one, constructing curves from the experimental data. In Figs. 7 and 8 such curves are drawn. In these curves the ordinates represent the values of P, and the abscissae represent the corresponding values of $\frac{t}{d}$, $\frac{t^2}{d^2}$ and $\frac{t^3}{d^3}$.

Fig. 7 is for drawn brass tubes. Fig. 8 is for cold-drawn seamless steel tubes. As all the lap-welded steel tubes tested by Prof. Carman were of about the same thickness and had thick walls, the data obtained from them has not been given. Instead a complete description of the tests made and the results obtained by Prof. Stewart in his extensive experiments on lap-welded Bessemer steel tubes will be given. An examination of these curves shows the following:

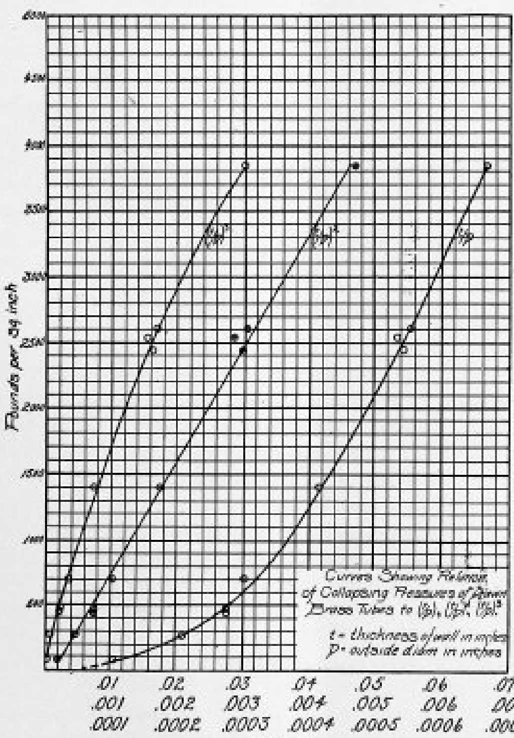


FIG. 7.

(1) For thin tubes; *i. e.*, for values of $\frac{t}{d}$ below about .025, the formula, $P = k \left[\frac{t}{d}\right]^3$ is very nearly true. This assumes that for this portion of the curve of P and $\left[\frac{t}{d}\right]^3$, the curve is practically a straight line.

The constants have been calculated and the formulæ are as follows:

(a) For thin brass tubes:

$$P = 25{,}150{,}000 \left[\frac{t}{d}\right]^3$$

(b) For thin cold-drawn seamless steel tubes:

$$P = 50{,}200{,}000 \left[\frac{t}{d}\right]^3$$

All of the lap-welded tubes tested by us were thick tubes.

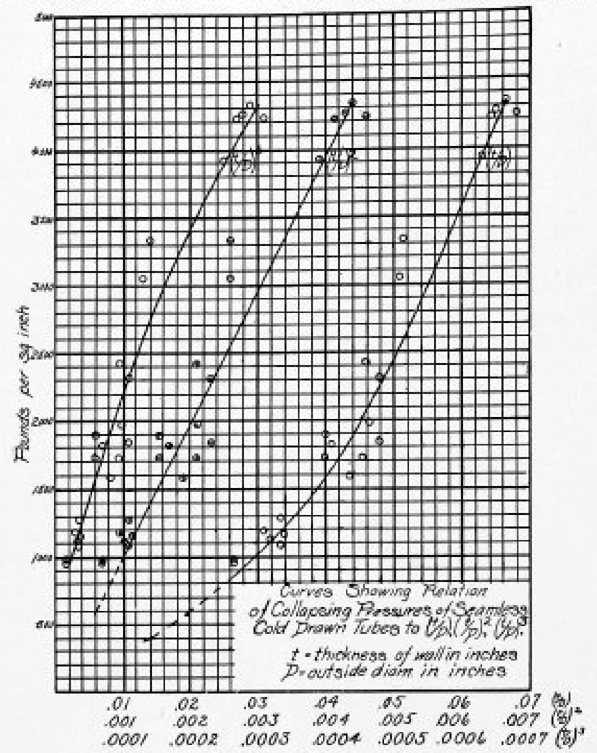


FIG. 8.

This formula with practically the same numerical coefficient applies to the thin tubes given in Stewart's tables of results.

(2) The curve of P and $\frac{t}{d}$ is nearly straight for the thick tubes; *i. e.*, for tubes having a value of $\frac{t}{d}$ greater than about .03. For thinner tubes, the curve bends rapidly toward the axis. The straight part of the curve can evidently be represented by an equation, $P = k \left[\frac{t}{d}\right] - c$, where k and c are constants. We have calculated these constants from our data, and find the following formulæ for tubes having a ratio $\frac{t}{d}$ greater than .03:

(a) For brass:

$$P = 93{,}365 \frac{t}{d} - 2474;$$

(b) For seamless cold-drawn steel:

$$P = 95{,}520 \frac{t}{d} - 2090;$$

(c) For lap-welded steel:

$$P = 83{,}270 \frac{t}{d} - 1025.$$

Prof. Stewart found for his lap-welded tubes the formula

$$P = 86{,}670 \frac{t}{d} - 1386.$$

(3) An approximate formula of the form $P = k \left[\frac{t}{d}\right]^2$ is suggested by the curves of P and $\left[\frac{t}{d}\right]^2$ particularly for the steel tubes. For cold-drawn seamless steel tubes, this approximate formula is

$$P = 1{,}000{,}000 \left[\frac{t}{d}\right]^2$$

and this can be used for tubes for which $\frac{t}{d}$ is less than .06.

For lap-welded steel tubes the same formula becomes

$$P = 1{,}250{,}000 \left[\frac{t}{d}\right]^2$$

and this can also be used for values of $\frac{t}{d}$ less than .06.

This approximate formula has been useful to us in getting probable collapsing pressures, and gives satisfactory rough values for tubes of the most common commercial thickness.

In applying any formula to calculate the collapsing pressure of a particular tube, a considerable factor of safety should be used. The constants in all these formulæ are large, and $\frac{t}{d}$ (or a power of $\frac{t}{d}$) is a comparatively small quantity, so that a small change in the numerical value of $\frac{t}{d}$ greatly affects the result. Lack of uniformity in the material, and slight deformations are also very important factors. It is to the credit of modern manufacturers of tubes that their product is as uniform as these tests show. With the knowledge which this discussion gives of the law of tube collapse, the user of tubes is in a position to calculate with fair approximation the collapsing pressure, particularly if he can get tests made of one or more sample tubes of the material so as to fix the constants.

While the experiments performed by Prof. Carman included tests of brass tubes, cold-drawn seamless steel tubes and lap-welded steel tubes, the experiments of Prof. Stewart were confined entirely to tests upon Bessemer steel lap-welded tubes from 3 to 10 inches in diameter, the product of the National Tube Company.

The Bessemer steel constituting these tubes had the following average physical properties:

Tensile strength, pounds per square inch	58,000
Yield point	37,000
Elongation in 8 inches, percent	22
Reduction of area, percent	57

And the following average chemical analysis:

Sulphur, percent	.069
Phosphorus, percent	.106
Manganese, percent	.35
Carbon, percent	.074

The hydraulic test apparatus used by Prof. Stewart in his experiments is shown in Fig. 9. The apparatus consists of the following:

I. A test cylinder with one head removable for the reception of the tube to be tested, this cylinder being provided with means for creating an hydraulic pressure within. This cylinder consisted of two sections with an aggregate length of about 30 feet. The sections were made from Bessemer steel lap-welded tubes, 16 inches outside diameter and ¾ inch thick, to which steel flanges were welded for the intermediate joints. Thickening rings were welded to the ends, intended to be threaded for the attaching of the heads. Two cylinders were used in the tests, one a 16-inch and the other an 8-inch. The 8-inch cylinder was only used where a very high fluid pressure was necessary. The heads for the 16-inch test cylinder were made from circular blanks punched from steel plates 2½ inches thick, and pressed into shape while hot by means of an hydraulic press. They were then fitted to the ends of the test cylinder, which had been reinforced with rings in the manner already described, by means of trapezoidal threads designed so as to resist stress in one direction. The flange joints connecting the different sections of the test cylinder were tongued and grooved, and were made up with leather packing in the bottom of the grooves. These joints each contained eighteen 1¾-inch steel bolts, and were fully as strong against internal pressure as the wall of the cylinder.

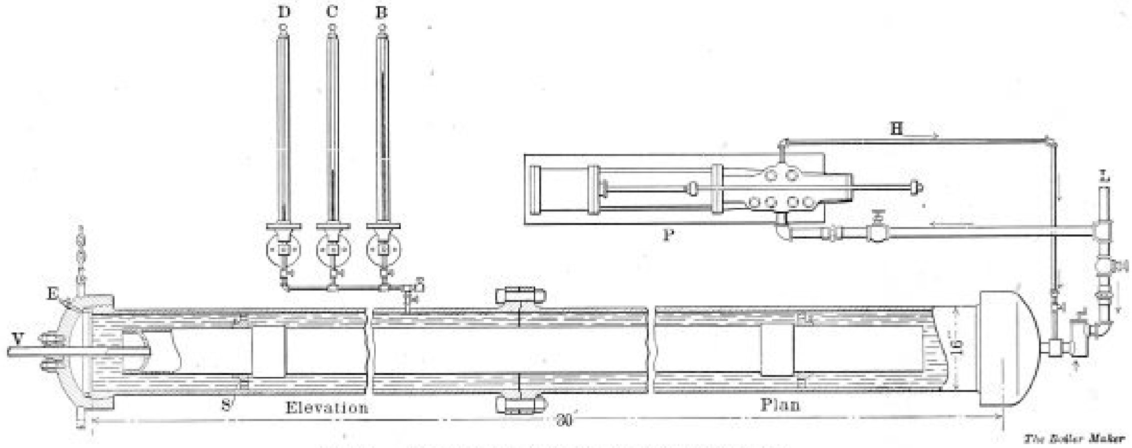


FIG. 9.—APPARATUS USED BY PROFESSOR STEWART.

II. A low-pressure water supply L of large volume, to rapidly fill the space within the test cylinder not occupied by the tube under test. For this purpose the rear end of the test cylinder was connected to the low-pressure water supply L of the works, and an air vent E, shown at the top of the left-hand head, Fig. 9, served the purpose of entirely freeing the cylinder from air and thus maintaining constant atmospheric pressure while the cylinder was being filled from the low-pressure supply.

III. A variable high-pressure water supply H, furnished by an hydraulic pressure pump P, the purpose of which was to create a fluid pressure within the test cylinder, the tube under test by this means being subjected to a gradually increasing fluid collapsing pressure. This high pressure supply was created by means of an hydraulic pressure pump capable of working against a fluid pressure up to 3,000 pounds per square inch. This pump was so controlled that the rate of increase of pressure at the region of expected collapse could be regulated to an exact rate, usually from 2 to 10 pounds per second.

which was screwed into the test head of the experimental tube, while the other passed through the end of the hydraulic cylinder to the atmospheric. Where it was not desired to keep the experimental tube central in the test cylinder a flexible vent

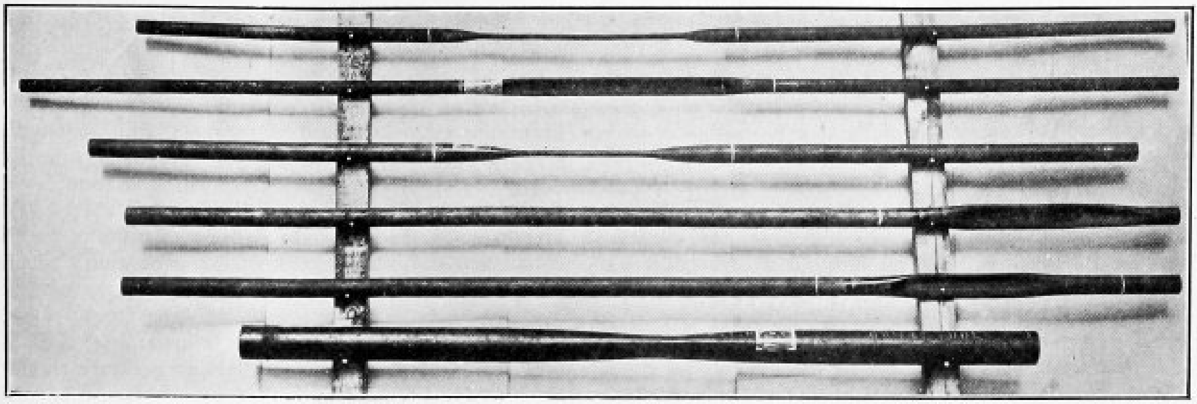


FIG. 10.—COLLAPSED TUBES, SHOWING POSITION OF FAILURE, AND THE RATIO OF ITS LENGTH TO THE LENGTH OF THE TUBE.

IV. A set of pressure gages, *B, C, D,* having a large range, connected so as they could be used either singly for indicated fluid pressure within the test cylinder or in combination for comparison of their readings. These gages were all of the Shaw deferential-piston mercury type, having capacities of 1,000, 3,000 and 8,500 pounds per square inch.

V. A vent pipe *V* leading from the interior of the tube under

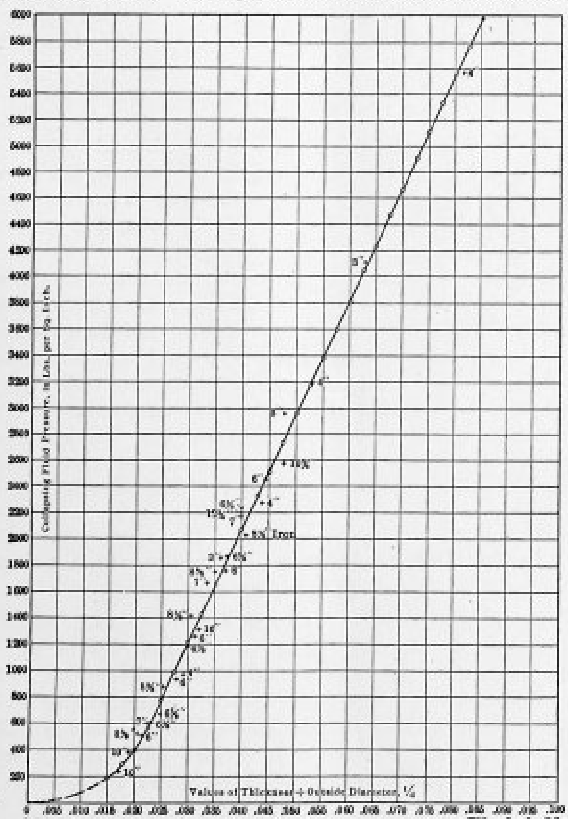


FIG. 11.—CURVE SHOWING RELATION BETWEEN COLLAPSING PRESSURE AND $\frac{t}{d}$ FOR LAP-WELDED BESSEMER STEEL TUBES. DATA FROM PROFESSOR STEWART.

test through the head of the test cylinder to the atmosphere, in order to maintain constantly an atmospheric pressure within the tube being tested. In some of the experiments, where it was desired to hold the tube central in the test cylinder the vent pipe consisted of a 1½-inch straight pipe, one end of

pipe, made by coiling a sufficient length of ½-inch gas pipe into a helical form, was used.

An autographic calipering apparatus was also constructed in order to determine the greatest and least diameters of the tubes at any desired point, especially at the point of collapse.

Prof. Stewart made two series of tests, the first of which

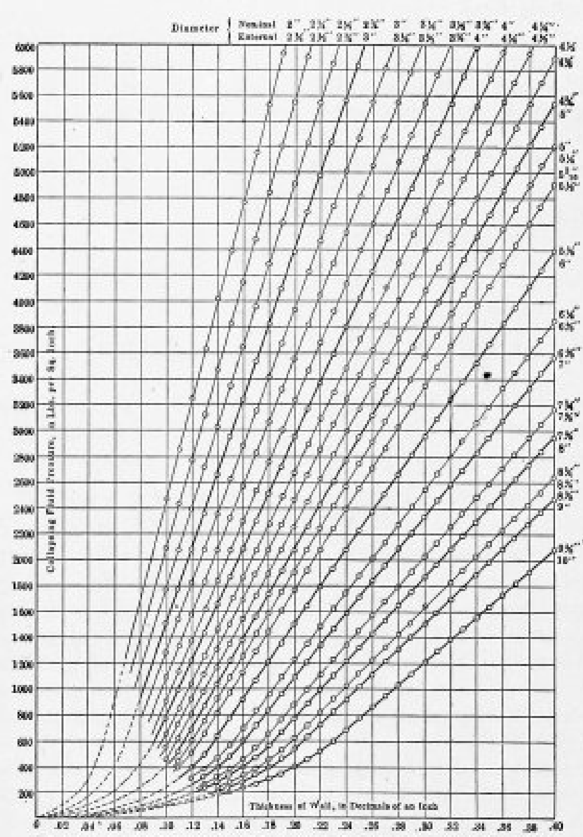


FIG. 12.—CURVES SHOWING RELATION BETWEEN COLLAPSING PRESSURE AND THICKNESS OF WALL FOR LAP-WELDED BESSEMER STEEL TUBES. DATA FROM PROFESSOR STEWART.

were on tubes of a certain diameter, but for all the different commercial thicknesses of wall and varying lengths. The chief purpose of this series of tests was to furnish data to determine which of the existing formulæ, if any, were applicable to modern lap-welded steel tubes and also to determine the effect the length of the tube would have upon the collapsing pressure. The result of these tests showed that the length of the tube between transverse joints, tending to hold it to a circular form, has no practical influence on the collapsing pressure of a commercial lap-welded steel tube so long as this length is not less than about six diameters of the tube. It also showed the inaccuracy of previous formulæ, in nearly all of which the collapsing pressure varies inversely as the length.

Having found that the length of the tube has no affect upon the collapsing pressure beyond a certain minimum critical length, the tests in series 2 were all made on 20-foot lengths of tube. The chief purpose of these tests was to obtain for commercial tubes the manner in which the collapsing pressure of the tube is related to both the diameter and the thickness of wall.

The results of these tests make it apparent that for tubes subjected to external fluid pressure, there are three principal variables involved; namely, the outside diameter d; the thickness of the wall t, and the fluid collapsing pressure p. It is also apparent that each of these variables is a function of the other two; that is, it depends jointly upon each of them for its value. By replacing two of these variables, t and d, by their quotient $\frac{t}{d}$ and treating this as a single variable, it was possible to plot the results of the tests for all diameters and thickness of wall on a plane surface. Fig. 11 shows the resulting plot.

An inspection of it shows that by far the greater number of values can be represented by a straight line formula. In fact, all could be thus represented except those having values of thickness divided by outside diameter less than .023. On a basis then for values of $\frac{t}{d}$ greater than .025, formula A was deduced as follows:

$$P = 86{,}670 \times \frac{t}{d} - 1386 \qquad \text{(A)}$$

For the values of $\frac{t}{d}$ less than .023 formula B was derived, assuming that this part of the curve when plotted would be tangent to the straight line represented by formula A, and would also be tangent to the horizontal axis at the origin O.

$$P = 1000\left(1 - \sqrt{1 - 1600\frac{t^2}{d^2}}\right) \qquad \text{(B)}$$

It was found that the apparent fiber stress on the wall of the tube at the instant of collapse varies all the way from about 7,000 pounds per square inch for the relatively thinest to 35,000 pounds per square inch for the relatively thickest walls. Thus the ability of a commercial stock tube to withstand a fluid collapsing pressure is not dependent alone upon either ultimate strength or elastic limit of the material constituting it.

While the value of the collapsing pressures of the tubes tested can be relied upon exactly, yet the collapsing pressure of any tube might fall below or above these values, due to inequalities in the thickness of walls. For this reason, a fairly large factor of safety should always be used when computing the collapsing pressure of a tube. For the most favorable practical conditions, that is, when a tube is subjected only to stress, due to fluid pressure, and only a slight loss could result from its failure, a factor of safety of 3 would appear sufficient. When only a moderate amount of loss could result from failure, use a factor of 4. When considerable damage to property and loss of life might result in the failure of a tube then a factor of safety of at least 6 should be used. When the conditions of service have caused the tube to become less capable of resisting collapsing pressure than when first installed, such as the thinning of the wall, due to corrosion; the weakening of the material, due to overheating; the creating of internal stress in the wall, due to unequal heating, vibration, etc., the above factor of safety should be increased in proportion to the severity of these actions.

On the chart shown in Fig. 12 are plotted for different diameters of tubes the fluid collapsing pressures in pounds per square inch for various thicknesses of wall. From this diagram the probable collapsing pressure of a tube of given diameter and thickness of wall can be found at once. Also the thickness of wall for a given diameter of tube can easily be found to withstand a certain working pressure as, for instance, if it is necessary to find what thickness of wall a 4-inch boiler tube should have in order to withstand a working pressure of 200 pounds per square inch with the factor of safety of 8, the result could be obtained as follows:

In this case the probable collapsing pressure should equal the working pressure multiplied by the factor of safety, or $200 \times 8 = 1600$ pounds. Looking on the curve for a 4-inch outside diameter tube at a pressure of about 1600 pounds, we find that the corresponding thickness of wall is nearly .14 of an inch, or about No. 9 B. W. G.

From the diagram, Fig. 11, we are able to find by means of a single curve the collapsing pressure for any ratio $\frac{t}{d}$. For example, by means of Fig. 11, find the probable collapsing pressure of a tube having an external diameter equal to 6 inches and a thickness of wall equal to .023. In this case, dividing the thickness of wall by the outside diameter, we get $\frac{t}{d} =$ .0338. Having found this vlaue on the horizontal scale and the corresponding point on the curve directly over it, the probable collapsing pressure may be read directly from the vertical scale at the left. In this case we find the collapsing pressure to be about 1540 pounds.

Thus we see that the results of this experimental work have given us means for determining accurately a probable fluid collapsing pressure of brass tubes, cold-drawn seamless steel tubes, and Bessemer lap-welded steel commercial tubes, and also means for determining the thickness of wall for a tube necessary to withstand a certain working pressure. It has, furthermore, been proved conclusively that the length of a tube has no influence upon this collapsing pressure when the length is greater than about six times the diameter of the tube.

Laying Out an Irregular Connection to a Cone.

BY J. N. HELTZEL.

Fig. 5 represents the cone and connection as it would appear when completed. Fig. 1. is the plan view of the cone and connection, the cone having outside dimensions and the connection inside dimensions. Space the semi-circles and flat sides of the connection into any number of spaces desired. In this case the connection is divided into fourteen spaces. Number the points on the curves and letter the points on the flat sides so they may be easily distinguished.

It will be noted that we have added an extra point X, this point is where the semi-circle of the connection is tangent to the side of the cone. At this point the connection will extend to the center of the cone, or in other words, it will be the longest point on the connection.

Through the points around the connection, draw lines perpendicular to the center line, extending to the center line only on each side. Mark the lines thus drawn the same as the points through which they pass, as 4, 3, X, 2, 1, $F1$, $F2$ and A, and also the series of points on the other side of the center line, as 5, F_3, F_4, etc. Next, draw the end view of the cone, Fig. 2. From all points around the connection, Fig. 1, pass lines parallel to the center line through Fig. 2 and letter and number these lines the same as points from which they are drawn.

We will now take the diameter of the cone at all these vertical lines, as 5, 3, F_4, etc., Fig. 1, on the upper series and transfer the different diameters on to the end view, Fig. 2, carrying the same to the center line only. Number and letter these circles to correspond with lines from which the diameters were obtained. Do likewise with the diameters on lower half of cone numbering and lettering in the ordinary way.

We can now complete the end view of the cone and connection and draw the line y, Fig. 2, which will be the base of the connection, the desired height. Now, where these lines intersect, a semi-circle of corresponding number or letter is the height or length of that line. A curve drawn through these intersects the slant height of the cone P, P. With C as a center, Fig. 4, draw the arc 5, carrying it to the center line only. Do likewise with all the distances on upper and lower half of the cone, numbering and lettering these radii the same as they were in the figure from which they were obtained.

Having completed all these arcs, we will now get the distance the opening will extend around these arcs. Working from the center line, Fig. 2, measure around the circle X to where the straight line X intersects the circle X. Mark this distance around the arc X, Fig. 4, measuring from the center line. Measure around all these circles, Fig. 2, and transfer the distances thus obtained to the corresponding arcs, Fig. 4, thus giving us the cutting line of the opening. Mark off the rivet line, also the holes, thus completing the cone.

In case the cone should be made of heavy metal, it would be necessary to allow for the stretching of the metal, or the hole would be too long to accommodate the connection.

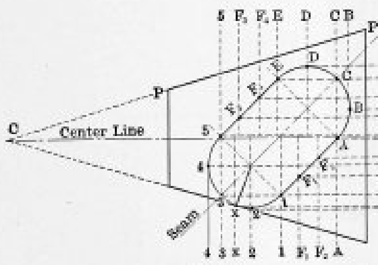


FIG. 1

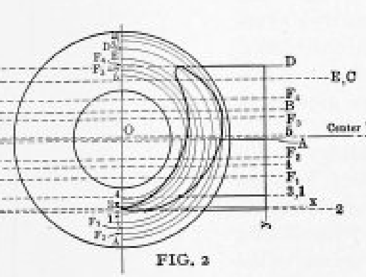


FIG. 2

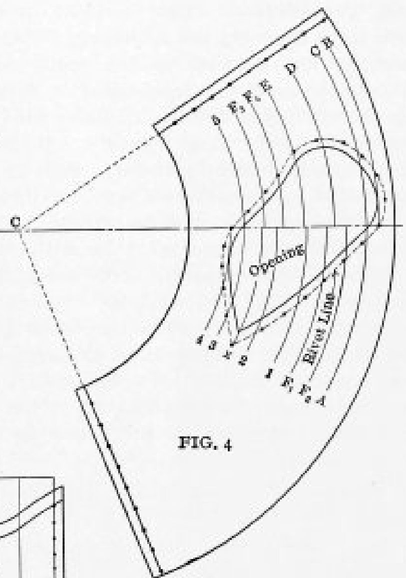


FIG. 4

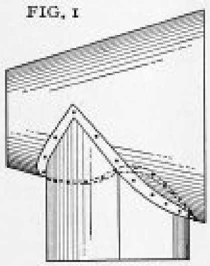


FIG. 5

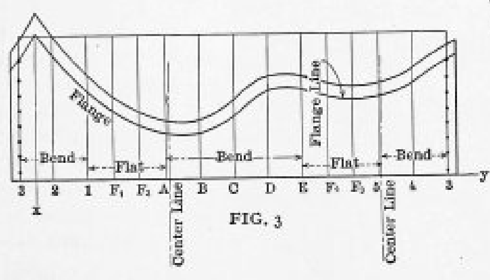


FIG. 3

points of intersection will be the end view of the hole as it would appear in Fig. 4 rolled together.

We can now proceed to lay out the pattern for the connection, Fig. 3. Draw the base line of Fig. 3 equal in length to the distance around the connection. This may be determined by figures. Space the bending portions of the sheet with the same number of parts as semi-circles in Fig. 1. Also space the flat sides into the same number of parts as in Fig. 1, numbering and lettering to correspond, as will be noted in Fig. 3. Working from the base line y, take the length of the line 3, that is, from where the straight line 3 intersects the curved line at semi-circle 3, transfer it to lines 3 and 3 on the pattern. This will be the seam, and when bent in shape will bring out seam at point 3 on Fig. 1. Transfer the lengths of all the lines, Fig. 2, thus completing our pattern for the connection, mark off the lap and flange lines and also the rivet holes in the seam. Center line Fig. 3, will be parallel with center line Fig. 1, when in position.

We will now lay out the cone and the opening in same. Lay out the cone in the ordinary way from the apex C, Fig. 1. Having the cone laid out we will have point C, Fig. 4.

With C, as a center Fig. 3, take the distance to where line 5

Vibration Tests of Rigid and Flexible Staybolts.

When the excellent report of the committee on flexible staybolts was up for discussion at the last convention of the Master Mechanics' Association, Mr. Wm. McIntosh, superintendent of motive power of the Central Railroad of New Jersey, presented some interesting data on the relative endurance under vibration, of rigid and flexible stay-bolts of various types, as his contribution to the sum of stay-bolt information. As is well known, Mr. McIntosh is an original and painstaking investigator of all factors concerning locomotive maintenance, therefore his work bears the stamp of authoritative accuracy, and the following particulars of his tests will be of the greatest value to those interested in fire-box staying.

"Some five years ago we commenced applying flexible staybolts and with several thousand of them in service, we have removed samples occasionally to determine their condition. Very recently we have discovered indications in two cases of fracture commencing under the ball in the shank of the bolt. So it would appear from this that there is a limit to that type of bolt, although the service has been markedly superior to any that we obtained from the ordinary bolt. We are using another flexible bolt now to a considerable extent, and desiring information about it we undertook a vibratory test that, while I do not consider that it gives accurate information it will be of some value, if it serves no other purpose than to lead to further investigation in that direction.

"I will give a brief statement showing how the test was conducted. It consisted essentially of putting four bolts into sheets of fire-box steel representing the inner and outer sheets of the boiler and fire-box. These were placed 4½ inches centers, as they would be in service, the plates being of regular fire-box and boiler thickness. Between these plates we placed a spring with the equivalent force of the boiler pressure. This had a tendency to press the plates apart in the same ratio. We clamped the outer sheet to a table, and the inner sheet to a beam that was arranged to be operated back and forth by power, with a total of 3-32 inch movement in either direction. The beam was moved by a ram, one end of it being held by a pin connection to the table of the machine, and the other driven by a connecting rod from a crank. This movement was kept up continuously until the bolts commenced to break, and until there was only one remaining. These results seemed to show that the machine worked nearly uniformly on the various samples, and the fractures that developed were due entirely to the binding action. With the solid bolts they averaged more uniformly than they did with the flexible bolts. There were considerable variations with the latter, but this was attributed to the different pressure that was applied to them in screwing them into the sheets.

"The results, as a whole, were decidedly surprising. I will state briefly that the variation in the breaking points between the flexible bolt and the rigid bolt ranged from 7,480, the largest number that the rigid bolt stood, to 53,630, the largest number that the flexible bolt stood in conditions as nearly the same as we could apply them. These were all 1-inch bolts. The average number of vibrations which the four bolts stood before breaking is given in the following table."—*Railway Master Mechanic.*

VIBRATION TESTS OF ONE INCH STAYBOLTS, 4½ INCH CENTERS.

TEST No.	Kind of Bolt.	Average Vibrations of Four Bolts.	Where Broken.
1............	Hollow Bolt.	4,813	Both Sheets.
2............	Hollow Bolt.	3,947	Outside Sheet.
3............	Solid Bolt.	4,812	Outside Sheet.
4............	Solid Bolt.	5,576	Outside Sheet.
5............	Solid Bolt.	6,935	{ 3 Outside Sheet. 1 Inside Sheet.
6............	Flexible Bolt.	21,706	Inside Sheet.
7............	Flexible Bolt.	29,410	Inside Sheet.*
8............	Flexible Bolt.	32,477	Inside Sheet.*

No holes were drilled in the ends of the solid bolts. *One bolt not broken, account being loose in sheet.

Cutting Steel by a Combustion Process.

BY S. D. BURR.

We are indebted to a Belgian engineer—Felix Jottrand, of Uccle—for the perfection of a process which, according to reports that have reached this side, is both rapid and economical, and, further, is capable of wide application. The process depends upon the union of oxygen and iron, and is founded upon the principle that when combustion has once been started it will continue as long as the proper conditions are maintained. More than this, when the metal has been heated to the requisite degree the temperature may then be increased by chemical action until the molten state has been attained. In other words, the union may take place with such great rapidity as to melt the metal. This method is not progressive from one chemical combination to another, and is the thermit process, but the start and finish are much nearer together.

Two elements having an affinity for each other will unite, and the violence with which the union takes place, or the combustion, as it is more generally termed, depends in most cases upon the temperature. Oxygen and iron will unite very slowly when both are cold, and very rapidly when the iron is heated and the oxygen is brought into proper engagement with it. This is the principle which has been utilized by M. Jottrand. Not the least important feature of the process is its wonderful simplicity. The metal, iron or steel, is first heated along the line of cut with an oxy-hydrogen flame. Following immediately in the path of this is a jet of oxygen, and the resulting oxidization is so rapid as to reduce the metal to a fluid state; in this condition it flows freely from the cut.

According to Eugene Lemaire, who describes the process in a recent issue of *Le Nature,* of Paris, the first experiments

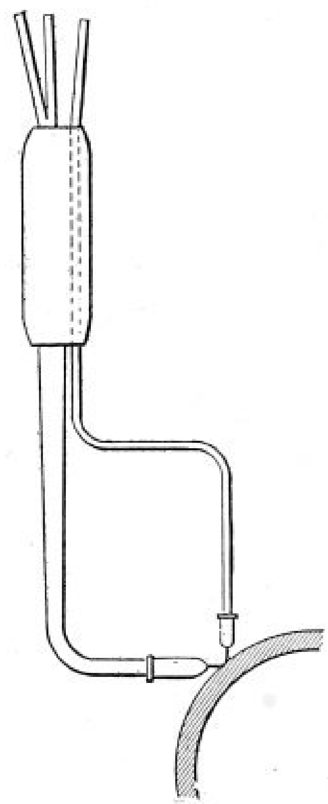


FIG. I.—THE CUTTING APPARATUS.

were made with an oxy-hydrogen flame to bring the metal to a red heat; when this temperature had been reached the hydrogen supply was reduced and that of the oxygen increased, the idea being to produce combustion. It was found that this action was not violent enough; the oxidation was too slow, and the metal could not be made fluid enough to flow freely from the cut. Carried out in this manner the operation was intermittent. Combustion could only be maintained for a few seconds at a time and then the metal had to be again heated with the oxy-hydrogen jet. The kerf was of varying widths and its edges were rough, while the repeated heatings were too prodigal in the use of hydrogen.

Success was attained when two jets, one carrying the oxygen and hydrogen and the other the oxygen, were moved along the mark. The first brought the metal to a red heat and the second provided the oxygen for combustion. The first jet was kept a short distance in advance of the second. Under these conditions the heat did not have time to be dissipated and the oxide was very fluid. Rapidity of cutting was assured, as the work was continuous. The expense of cutting was reduced, as there was no waste of gases, both the oxygen and hydrogen being used under the most efficient circumstances.

It is mentioned that the section cut is as clean as that left by a saw, and the kerf is not over 2 millimeters (0.078 inch) wide in a plate 100 millimeters (3.93 inches) thick. The rate of cutting is 20 centimeters (7.87 inches) per minute for a plate 15 millimeters (0.59 inch) thick. The consumption of hydrogen and oxygen for this amount of work is only a few liters (1 liter = 61.022 cubic inches) of each. The line of cutting may follow any direction desired, and variations in the character of the metal have no influence on the cutting. The process is equally applicable to hard or soft steel, and has been advocated for the dressing of armor plate.

Letters patent have just been issued in this country to M. Jottrand. In the specifications this method is advanced for cutting plates, pipes and other metal articles made of iron or other readily oxidizable metal. For cutting openings in pipe or plate the jets are turned about a center in sweep fashion.

It is explained that the cutting of the metal is effected by chemical action upon the heated part, "the metal being raised

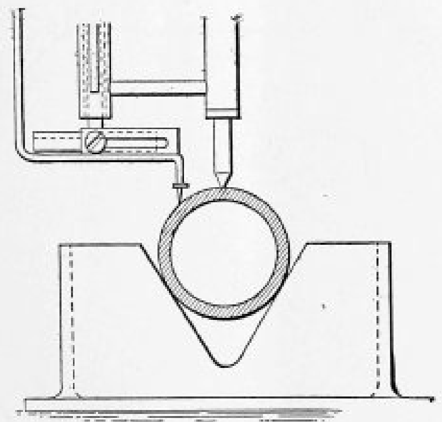


FIG. 2.—NOZZLES ATTACHED TO A CENTER.

to such a temperature as to enable oxidation to take place without fusion of the metal, while the oxides, which are more fusible than the metal itself, flow readily and the severance is perfectly clean, as though the metal had been sawed."

The construction of the device will be understood from the accompanying illustrations, which are taken from the patent papers. When the work does not require any great degree of precision, or when the contours to be cut are quite complicated, an ordinary blowpipe is employed, indicated in Fig. 1. This is provided with separate inlets for the oxygen and hydrogen which open into the mixing chamber, from which leads a nozzle, whence issues the heating jet against the metal. To this blowpipe is fixed a pipe, which conducts oxygen under pressure to the nozzle. This nozzle is arranged to follow closely in the path of the first, so as to direct its jet upon that portion of the metal which has been brought to the proper temperature by the flame. This jet of oxygen produces a clean cut along the line and without appreciable loss of metal.

The second drawing, Fig. 2, shows the nozzles carried by a center, which is applied to a pipe. It is evident that the same arrangement can be applied to a plate for circle cutting. Extending from the center is an arm at the lower end of which is a stud engaging with a slotted bar to which the gas pipes are attached. By this means the device can be arranged to cut in circles of different diameters.—*Iron Age.*

Difference in Temperature in the Tubes of a Return Tubular Boiler.

An interesting experiment, performed by a certain engineer to determine the difference in temperatures in the tubes of return tubular boilers, is related by Mr. Chas. T. Porter in "Power." This engineer had a battery of return-tubular boilers, each one crammed full of tubes according to the usual methods of boiler makers. He provided himself with pieces of lath 1 inch wide, ⅛ inch thick, 4 inches long, and laid one in the front end of each tube in one of his boilers and left them there for 24 hours. He had made a diagram of his boiler, on which he numbered every tube and put a corresponding number on every piece of lath. In taking them out they presented an astonishing revelation, which he showed me. Some of the pieces were burned to a coal and some were scarcely discolored, while the great body of them presented various effects of heat between these extremes. This showed distinctly the enormous differences in the temperature of the gases passing through the different tubes, and that fully one-half of the tubes did little or no work in evaporating the water. They taught a lesson which boiler makers, who count every additional tube they can get into a boiler as so much added heating surface, and rate their boilers accordingly, have no anxiety to learn, but one which will be of value to plant owners.

Boiler-Riveting Plant at Messrs. Beardmores' Works.

The riveting plant erected in the boiler shop of the naval construction works of William Beardmore & Company, at Dalmuir, Scotland, presents a very convenient arrangement and one calculated to insure rapid handling of material at the riveter. The riveting machine is placed between two wide bays of the boiler shop, in line with the columns, so that the overhead crane at the riveter can deliver a boiler shell on either side, to be picked up by one of the traveling cranes in either of the two bays. The overhead traveling crane, which is capable of lifting a load of 75 tons and of traversing it to a distance of 12 feet on either side of the center line of the machine, is carried on two girders running at right angles to the main girders of the shop and supported on four independent columns braced to the shop columns by angle-iron ties. This crane, like all the other electric cranes in the works, was made by the Glasgow Electric Crane & Hoist Company, Ltd., Parkhead. It has a span of 24 feet, and is designed for a load of 75 tons, the height to the crane rails being about 43 feet. Boilers of any diameter and up to about 24 feet long can be suspended from it.

The longitudinal travel of the crane and transverse motion of the crab, as well as the main hoist, are each operated by a separate motor of the enclosed ventilated reversible type. The following are the particulars of the three motors:

	Horse-power	Revolutions Per Minute.
Motor for hoisting	30	500
Motor for traveling	20	600
Motor for traversing	20	600

The power for the hoist-barrel is transmitted through a worm on the motor shaft, fitted with thrust bearings, and having an oil circulation, the oil being pumped from a tank on the crab. This worm gears into a worm-wheel, and by a further double reduction of spur wheels the motion is transmitted to the shaft of the hoist-barrel. The whole of the gearing on the crane is of steel, with machine-cut teeth. The following are the specified speeds at which the crane is designed to work with full loads:

	Feet Per Minute.
Hoisting	4
Longitudinal traveling	60
Cross-traversing	60

Besides the ordinary solenoid brake in the hoisting gear, the controller is provided with electric braking points for lowering. All the motions of the crane are controlled from the platform at the riveting machine, so that the man working the machine is able to adjust the position of the boiler to suit his requirements. The controller for the longitudinal and transverse movements of the crane is of the double controller universal type, so that the travel of the hook in a horizontal plane is controlled by one handle only. After erection the crane was satisfactorily tested in all its motions with a load of 112½ tons.

The riveting machine itself was made by Messrs. Crow, Harvey & Company, Parkgrove Iron Works, Glasgow. It is of the built-up type, having a gap of 12 feet 6 inches. With an accumulator pressure of 1,500 pounds per square inch, the closing pressure on the rivet head may be either 45, 90, or 146 tons; while with the intensifier, which is placed at the back of the machine, closing pressures on the rivet head of 64, 126, or 200 tons can be obtained. The machine is thus arranged to give any one of the six pressures on the rivet head. The highest pressure is used for closing the rings before riveting, a special pair of convex and concave dies being used for this purpose. The main frame of the machine is of box section of massive proportions, made from a very strong quality of cast iron. The hob, or holder-on, is of Siemens cast steel, of large proportions, to prevent it springing, and it is bolted to the main frame of the machine by two forged steel bolts with buttress threads, these bolts passing through the holder-on and the main frame. On the top of the main frame is a large steel casting containing the cylinders and forming the guide for the slide of the moving snap. This casting is provided with large snugs to receive the thrust, and is also bolted to the main frame. The two cylinders are also of Siemens cast steel, each lined with gun metal. All the valves, which are of Crow, Harvey & Company's improved design, are conveniently arranged at one side of the machine and easily under the control of one man.—*Engineering.*

Elementary Problems in Laying Out.

Problems frequently come up in both boiler and sheet-metal work in which it is necessary to find the development of the surfaces of cylinders which intersect each other or are cut by plane or curved surfaces. One of the simplest of these problems is that in which two cylinders of the same or different diameters intersect at right angles, as shown in Fig. 18.

The development of the small cylinder, which is shown in Fig. 19, may be found in the following manner: Draw a plan or half-plan view of the cylinder and divide it into any convenient number of equal parts. In this case the half-plan is shown dotted just above the cylinder, with the semi-circumference divided into eight equal parts. Project these points of division down to the elevation and draw the parallel lines 1-1, 2-2, 3-3, etc. Then lay out the line 1-1, Fig. 19, equal to the circumference of the cylinder. Divide 1-1 into sixteen equal parts to correspond with the divisions in the plan. Draw the parallel lines 1-1, 2-2, 3-3, 4-4, etc., at right angles to 1-1 at these points of division and lay off upon each its proper length as measured from the top of the cylinder in the elevation, Fig. 18, to the surface of the large cylinder at the line of intersection. A smooth curve drawn through these points defines that edge of the development.

If the small cylinder were to be made of a plate rolled to the proper diameter and flanged at the lower edge for a riveted joint to the large cylinder, it would be necessary to make the line 1-1 equal to the circumference corresponding to the mean diameter of the cylinder measured to the center of the plate. This would give the distance between the rivet lines and the laps, equal to 1½ times the diameter of the rivets should be added outside this. The lower edge of the development as shown in Fig. 19 would then be the flange line, and the edge of the plate should be located at a distance below it sufficient to give the desired width of flange after flanging, or approximately the width of flange minus two times the thickness of the plate.

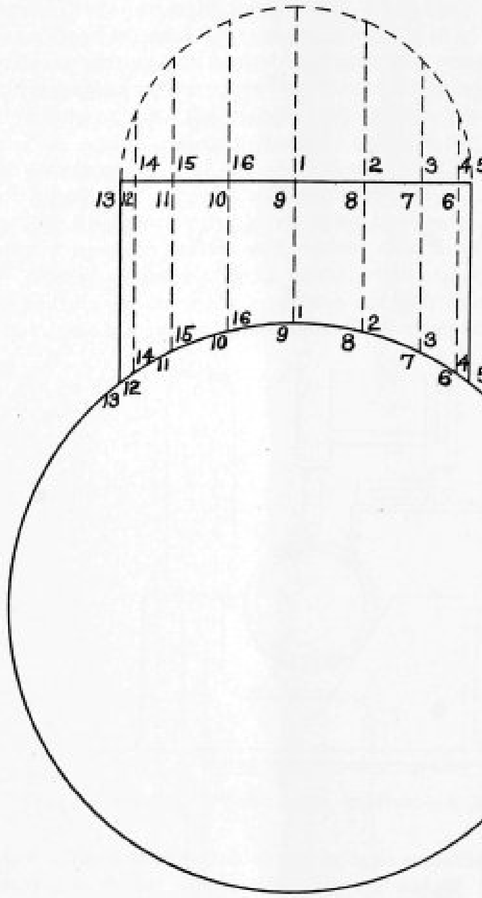


FIG. 18.

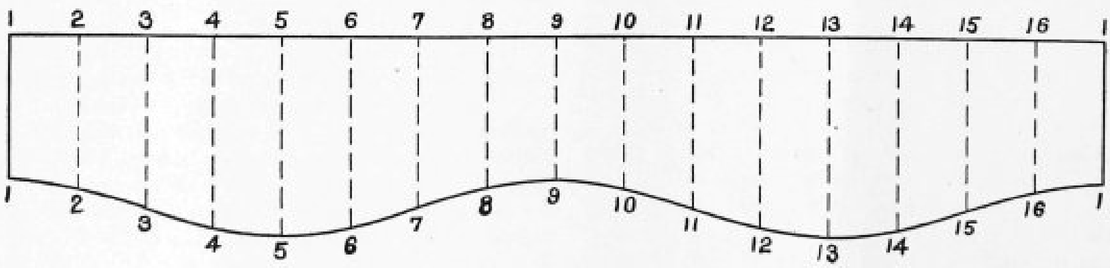


FIG. 19.

To get the development of the opening in the large cylinder at the line of intersection it would be necessary to draw a side elevation of Fig. 18; draw the parallel lines on the small cylinder, and then project the points 1, 2, 3, 4, etc., from the large cylinder across to the respective lines 1-1, 2-2, 3-3, 4-4, etc., in the side elevation. The lines which were used in projecting the points from one elevation to the other would of course be parallel and might be used as the parallel lines in the development. These will not, however, be spaced equally on the circumference of the large cylinder, for as can be seen in Fig. 18, the spaces 1-2, 2-3, 3-4, etc., are unequal. Therefore care should be used in spacing them in a corresponding manner in the development.

In Fig. 20 is shown a cylindrical coal chute leading from a floor forward at an angle through a wall. Here we have two

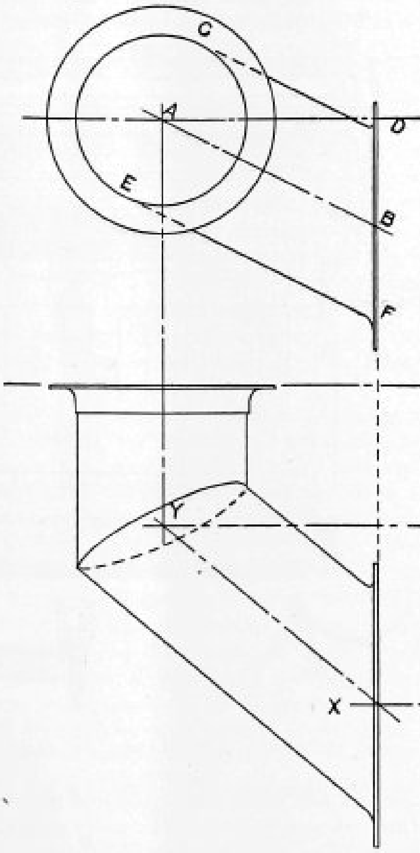


FIG. 20.

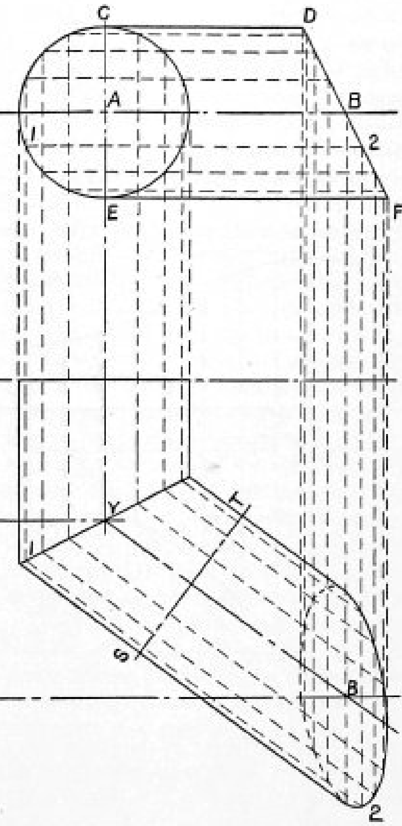


FIG. 21.

cylinders of the same diameter, intersecting at an angle and also one of the cylinders cut by a plane surface at an angle. In this problem it will be seen that the line of intersection of the two cylinders must be determined before the lengths of the parallel lines on the surfaces of the cylinders can be obtained. Furthermore, since the inclined section of the chute appears foreshortened in both the plan and elevation, the true lengths of parallel lines drawn upon its surface will not be shown in either plan or elevation.

The projection of the cylinders upon a vertical plane par-

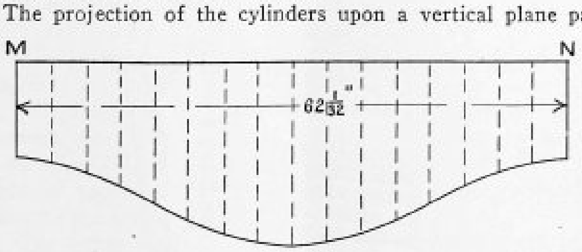


FIG. 22.

allel to the axis of the inclined section will show the true lengths of all lines parallel to the axis of either cylinder. Such a view is shown in Fig. 21. The plan, Fig. 21, is exactly like the plan, Fig. 20, except that the axis of the inclined section has been taken parallel to the plane of the paper. Therefore, the distances *A B, C D, E F*, etc., Fig. 21, are equal, respectively, to the distances *A B, C D, E F*, etc., Fig. 20. In order to draw the elevation, Fig. 21, project the point *B* down from the plan to the line *X X*, locating one end of the axis of the cylinder. The other end of the axis may be projected over to the line *Y Y* from Fig. 20. Then the outline of the cylinder will be drawn parallel to this line.

The lower end of the inclined section will appear as a curve and must be determined as follows: Divide any cross-section of the cylinders, as the plan view of the vertical section, into a convenient number of equal parts, and from these points of division, draw lines parallel to the axis of the cylinder in both plan and elevation, lettering or numbering the corresponding lines to avoid confusion. Then to locate any point, as 2, in the elevation, project the point 2 from the plan down to the line 1-2 in the elevation. Do the same for each point at the lower end of the inclined section and then draw a smooth curve through these points, completing the elevation.

Since the true length of each of the parallel lines is shown in the elevation, Fig. 21, the development of the two sections forming the chute may now be laid out in the usual manner. Assume that the outside diameter of the vertical section is 20 inches, and that the thickness of the plate is ¼ inch. Then the mean diameter of the vertical section will be 62 1-32 inches.

```
   3.1416
    19.75
  -------
   157080
  219912
 282734
 31416
  -------
 62.045600" or 62 1-32"
```

Lay out the line *M N*, Fig. 22, for the top edge of the plate, 62 1-32 inches long, and divide it into 16 equal parts to correspond with the divisions in Fig. 21. Draw parallel lines at right angles to *M N* from these points; then on each of these lines lay out its length as shown in the elevation, Fig. 21. This will locate the flange line and the necessary amount for the flange must be added below this. In Fig. 22, both laps and flange have been omitted.

Since the vertical section fits inside the inclined section, the mean diameter of the inclined section will be 20¼ inches. The length of the plate will therefore be 63⅝ inches.

$$
\begin{array}{r}
3.1416 \\
20.25 \\
\hline
157080 \\
62832 \\
62832 \\
\hline
63.617400'' \text{ or } 63\tfrac{5}{8}''
\end{array}
$$

As it is not necessary to have a close fit in this case, make this length 63¾ inches.

As there is an irregular cut at each end of the plate, take

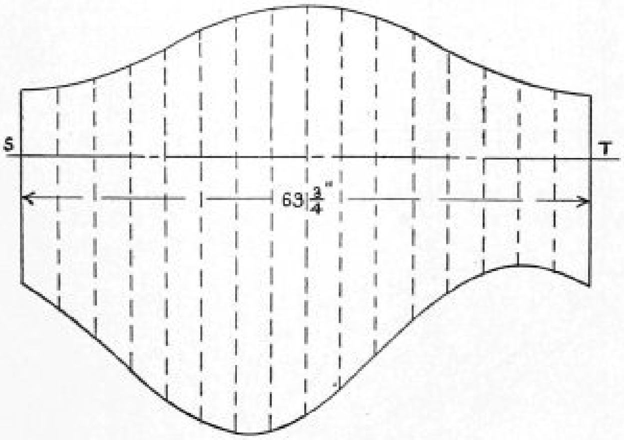


FIG. 23.

a cross-section at any point in the cylinder as the section *S T*, and measure the length of each of the parallel lines from this section in both directions. Lay out the line *S T*, Fig. 23, 63¾ inches long; divide it into sixteen equal parts, drawing lines at right angles to *S T* at these points; and lay off the lengths of these lines as measured from the elevation, Fig. 21. This gives the development of this plate to the rivet and flange lines.

Without giving further examples it will be seen that the development of any cylindrical surface can be obtained in the manner above described if a projection of the solid on a plane parallel to its axis can be drawn. If the axes of two or more intersecting cylinders lie in the same or parallel planes, such a projection may be obtained. If their axes do not lie in the same or parallel planes, it will be necessary to find the true lengths of the parallel lines on each solid separately.

A New Water Tube Boiler.

The accompanying illustrations represent new features in cross-tube sectional water tube boilers, having two sets of tubes, the upper set being the cross-tubes and the lower set staggered. The cross-tube series are arranged so that the tubes come one directly over the other in series which are alternately inclined in opposite directions. The tubes are set at an angle of about 45 degrees. The lower set are staggered and slightly inclined. The heat from the furnace strikes the staggered set of tubes and is deflected by baffle plates above the staggered tubes so as to direct the gases to a combustion chamber where they are mixed with air and ignited, after which the gases pass over the upper set of tubes, longitudinally, and thence into the outlet flue to the stack. It is claimed that this method of utilizing the heat elements insures an economic consumption of coal, that the flue temperatures are low, the firing of the boiler easy, and that the boiler will produce steam of a dry quality quickly.

The circulation of the water is as follows: The water enters the steam and water drum and passes into the saddles, which are located at both ends of the boiler under the drum, thence into the tubes which connect the saddles and the downtake tubes, thence to the side-water legs and then into the mud-drums. From here it passes into the lower set of headers and the staggered set of tubes, thence into the upper

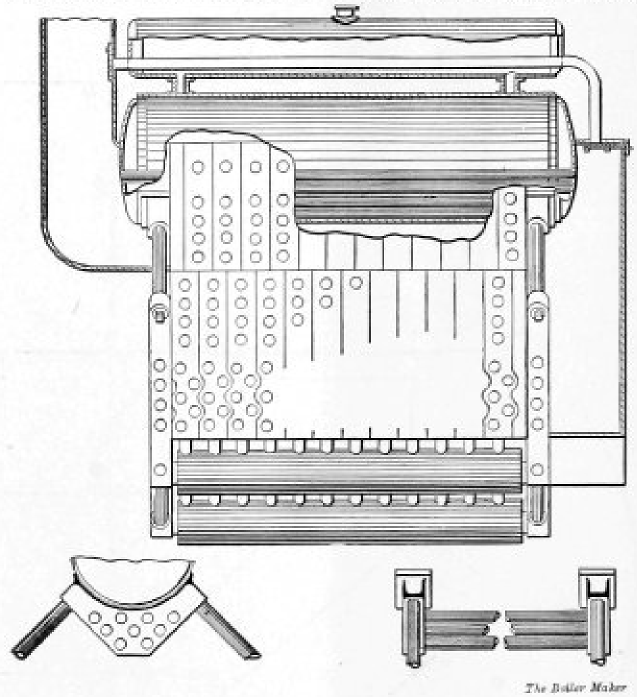


FIG. 1.—SIDE ELEVATION AND DETAILS OF SADDLE OF DEL MAR BOILER.

set of headers and tubes, and finally into the steam and water drum from whence it came. The gases pass through the set of staggered tubes into a combustion chamber, thence over the set of cross-tubes, also through the fire tubes, which are in the steam and water drum, also, if desired, by means of a

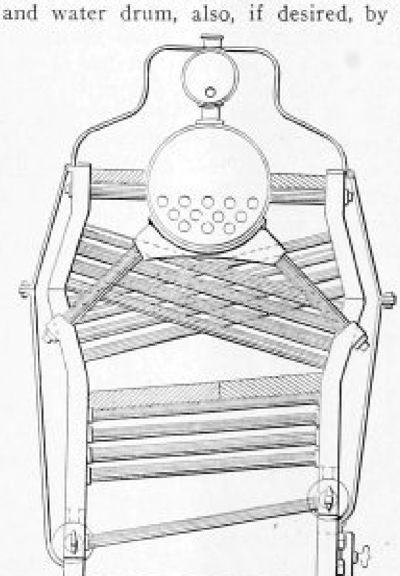


FIG. 2.—END ELEVATION OF DEL MAR BOILER.

damper, through the tube, which is in the super-heater, into the outlet of flue.

The principal features of the boiler which distinguish it from cross-tube sectional water-tube boilers of other designs are: the super-heater and steam drum; means for passing the heat through the tube in the super-heater; the steam and water drum with the fire flues; the saddles at the ends of the drum from which the down-take tubes issue, which keep these tubes clear of the brick work which is usually at both sides of the boiler and into which these tubes are imbedded; the side-water legs which permit the down-take tubes to be easily cleaned and inspected; the equalizing tubes which connect the two mud-drums, they being independent of brick work; the rear mud-drum being lower than the front drum, for the purpose of allowing the sediment to settle; the baffle plates above the staggered set of tubes to direct the course of the gases to the combustion chamber; the combustion chamber; the baffle plates at the top of the boiler; the dampers which control the gases. The super-heater may be dispensed with altogether, in which case the lower drum would not have as many fire tubes, or possibly none at all. The equalizing tubes can be dispensed with altogether and a set of tubes to take their place can be inserted so as to connect the side-water legs, which would equalize the water in both sides of the boiler.

There are nine other patents issued to the same patentee covering improvements in features in cross-tube sectional water-tube boilers, the principal among which are: end water-legs, to take the place of the brick work, which is usual in this class of boilers, and which make the boiler a desirable marine boiler as it dispenses with all brick work; an improvement in door manifolds, there being end openings in the manifolds, besides the series of manifolds being connected together by means of tubes. In this construction the manifolds can be cleaned longitudinally and the circulation of the boiler uninterrupted. This will be of interest to those who have door manifolds with closed ends. This boiler is placed on the market by Del Mar & Myers, 95 Liberty street, New York.

Specifications for a Three-Furnace Single-Ended Scotch Boiler.

The following is a typical set of specifications for a Scotch boiler. While the figures quoted apply to a boiler which is to be installed on the United States revenue cutter No. 16, the requirements represent the best of marine boiler construction at the present time.

The Boiler.

The general dimensions of the boiler will be:

Diameter of shell (inside), 13 feet 6 inches.

Length over heads (bottom), 10 feet 3 inches.

Number of furnaces, three.

Diameter of furnaces (inside), 40 inches.

Total grate surface, 60 square feet.

Total heating surface, 1,803 square feet.

The boiler shall be designed for a working pressure of 180 pounds per square inch.

The design of this boiler will be furnished by the government. The various details will be worked out by the contractor and submitted to the Engineer in Chief, U. S. R. C. S., for his approval, before work is commenced on the construction of the same.

The boiler shell will be made in one course and will consist of two plates 1¼ inches thick.

Each head of the boiler will be made of two plates, the upper one being 15-16 inch thick and the lower one ¾ inch thick. The front head will be flanged outwardly at the furnaces and both will be flanged inwardly at the circumferences. The front head will be stiffened by angle bars and the back head by doubling plates riveted on, all as shown on the drawing.

The tube sheets will be ¾ inch thick. They must be accurately parallel, and all tube holes will be slightly rounded at the edges. The holes for the stay tubes will be tapped together in place.

The boiler tubes will be of cold-drawn seamless mild steel, the best that can be obtained on the market, and subject to the approval of the engineer in chief. All tubes will be 3 inches in external diameter. The ordinary tubes will be No. 10 U. S. S. G. in thickness and will be swelled to 3 1-16 inches external diameter at the front end. The ends will be expanded in the tube sheets and beaded over at the back end. The stay-tubes will be No. 6 U. S. S. G. in thickness and will be upset at both ends to an external diameter of 3 3-16 inches, leaving the bore of the tube uniform from end to end. They will then be swelled at the front ends to 3 7-16 inches external diameter. They will be threaded (twelve threads per inch) parallel at the combustion chamber ends and taper at the front ends to fit the threads in the front tube sheet. They will be screwed into the tube sheets to a tight joint at the front ends and will be made tight at the back ends by expanding and beading. All the expanding will be done with approved tools. All of the tubes will be spaced 4 inches from center to center vertically and 4¼ inches horizontally.

There will be a separate combustion chamber for each furnace in the boiler, as shown on the drawing; they will be made of 9-16-inch plates at top and back and 19-32-inch plates at the bottom and sides, as shown. The tube sheets will be as before specified. The tops of the combustion chambers will be braced by steel-plate girders, with the edges machined, as shown. The plates will be flanged where necessary, and all parts will be joined by single riveting. The holes for the screw stay-bolts in the plates of the combustion chambers and shells will be drilled and tapped together in place.

The bracing will be as shown on the drawing. The combustion chambers will be stayed to the shell of the boiler by screw stays 1⅜ inches in diameter over the threads, with twelve threads to the inch, screwed into both sheets and fitted with nuts, the nuts to be set up on bevel washers where the stays do not come square with the plates. The washers will be cupped on the side next to the plates and the joint will be made with a cement of red and white lead and sifted cast-iron borings. Where the nuts set up directly on the plates, they will be cupped out and the joint made with cement. The combustion chambers will be stayed to the back heads by screw stays 1½ inches in diameter over the threads around the edges of the combustion chambers and 1⅜ inches diameter over the threads elsewhere. When the nuts are up in place, the washers must bear solidly against the plates with which they are in contact. The holes for all screw stays will be tapped in both sheets together in place. All joints around stays will be calked tight under 100 pounds hot-water pressure before the nuts are put on.

The upper through braces will be 2⅜ inches in diameter, upset on the ends to 2⅝ inches in diameter, and threaded eight threads to the inch. The nuts for the upper through braces will be of wrought iron set up on washers, inside and outside. The outside washers will be about 8½ inches in diameter and 15-16 inch thick in the two upper rows, and about 7½ inches in diameter and 15-16 inch thick in the lower row. The washers will be riveted to the heads by six ¾-inch rivets. The inside washers will be cupped for cement, as shown. No packing will be used.

All screw stays will have the thread cut in a lathe, the length between the plates being turned down to the bottom of the thread, as shown on the drawing.

All braces will be of steel, "Class A," and without welds, except the two 2-inch braces on the wing combustion chambers which will be made of wrought iron, as shown on the drawing. The crowfeet on the combustion chamber will be made of wrought iron. The screw stays will be made of steel, "Class B."

The longitudinal joints of the boiler shell will be butted with 1¼-inch straps, inside and outside, and treble-riveted, as shown on the drawing. Joints of heads and joints of heads with shell will be double-riveted, as shown. Joints in furnaces and combustion chambers will be single-riveted. All rivets will be of open-hearth steel, "Class B," except for the rivets in the longitudinal joint for the shell plates, where the rivets will be of "Class A."

The edges of all plates in the cylindrical shell and of all flat plates, including the girders for the tops of the combustion chambers, where not flanged will be planed. Edges of flanges will be faired by chipping or otherwise, as approved.

Plates in cylindrical shell must not be sheared nearer the finished edge than one-half the thickness of the plate along the circumferential seams and not nearer than one thickness along the longitudinal seam. All rivet holes will be drilled in place after the plates have been bent, rolled, or flanged to size, and fitted and bolted together; after the holes have been drilled the plates will be separated and have the burs around the holes carefully removed. Hydraulic riveting will be used wherever possible, with a pressure of 65 to 75 tons. In parts where hydraulic riveting cannot be used, the rivet holes will be coned on the driven side 1-16 inch.

Seams will be calked on both sides in an approved manner.

All joints will be as shown on the drawing.

Each furnace will be in one piece and corrugated. The thickness and the diameter will be as shown on the drawing. They must be practically circular in cross-section at all points. They will be riveted to the flanges of the front head and to the combustion chambers, as shown.

There will be manholes in the boiler of such size and location as shown on the drawing. The top manhole will have a stiffening ring, as shown. The manhole plates will be of cast steel in dished form, except the top plate, which will be made of steel plate, "Class B." Each plate will be secured by two wrought-iron dogs and two 1⅜-inch studs, screwed into the plate (twelve threads to the inch), fitted with collars, and riveted on the inside, and fitted with nuts for setting up on the outside. Each plate will have a convenient handle, and all plates, dogs, and nuts will be plainly and indelibly marked to show to what holes they belong.

The grate bars will be of cast iron and of an approved pattern. They will be so fitted as to be readily removed and replaced without hauling fires. The bars at the sides of the furnaces will be made to fit the corrugations. The bars will be made in two lengths, resting on the dead plate in the front and on the bridge wall in the rear of each furnace. They will be supported in the middle by an approved framework made to fit the corrugations. No holes will be drilled in the furnace for securing the furnace fittings. The area of opening between the grate bars will be about 40 percent of the grate area.

The bridge walls will be made of cast iron, as shown, and so fitted as to be readily removable. They will be covered at the top with approved fire bricks laid in cement. The area of opening above bridge walls will be about 16 percent of the grate surface. The tops of the bridge walls will be slightly crowned.

The furnace fronts will be made with double walls of steel, bolted to a sectional cast-iron frame. The space between the two walls will be in communication with the fire room. The inner plate of furnace front will be perforated as may be directed. The dead plates will be made of cast iron and so fitted as to be easily removable. The door openings will be as large as practicable.

The furnace doors must be protected in an approved manner from the heat of the fires. The perforations in the doors and lines will be as directed. Each door will have a small door near its lower edge for slicing the fires. There will be two wrought-iron hinges to each door and the latches will be of wrought iron. There will be an approved arrangement fitted to each door to prevent them from sagging, and also to hold them open when firing. The furnace-door liners will be made of cast iron ⅝ inch in thickness.

Ash pans of ¼-inch steel plate, reaching from the front of the furnace flue to the bridge wall, will be fitted to all the furnaces. The edges of the ash pans will be made to fit the corrugations of the furnaces.

The ash-pit doors will be made of 3-16-inch steel plate, stiffened with angle or channel bars. They will be furnished with suitable buttons, so as to close the ash pit tightly when the furnace is not in use. Each door will have two wrought-iron beckets to fit hooks on the boiler front. Wrought-steel protecting plates ⅜ inch thick will be fitted around the boiler front, sides and passages, as before specified, to serve as ash guards.

A lazy bar with the necessary lugs will be fitted to the front of each ash pit, and there will be three portable lazy bars for the furnaces.

The uptake will be made of double shells of steel No. 8 U. S. S. G., built on channel bars and stiffened with angles and will be bolted to the boiler head and to the smoke-pipe base. Outside of the uptake will be a jacket inclosing a 3-inch air space. This jacket will be made of No. 12 U. S. S. G. steel. The space between the plates of the uptake will be filled with magnesia blocks containing not less than 85 percent carbonate of magnesia.

The uptake doors will be made of double shells of steel of the same thickness as the uptake and will have an air jacket like the uptake. The space between the shells will be filled with magnesia blocks. The hinges and latches will be made of wrought iron. Each door will have an eyebolt near its top for handling and one near the bottom for convenience in opening.

The boiler will rest in two approved saddles, built up of plates and angles. It will be secured to the angles by standing bolts screwed into the boiler shell, with nuts inside and outside, the inside nuts setting up on snugly fitting washers, with cement joints. These bolts will fit holes in the angle bars of the front saddle snugly, but pass through enlarged holes in the angle bars of the back saddle to allow for expansion. Chocks built up of plates and angle bars will be fitted at each end of the boiler, as approved, so as to prevent any displacement of the boiler. The boiler will be secured, in addition to the above, by four 1½-inch holding-down bolts connecting cast-steel palms bolted to the boiler shell and riveted to tank tops and reverse frames of the vessel, as approved.

The boiler will be clothed with magnesia blocks, securely wired in place and covered with galvanized iron, in an approved manner.

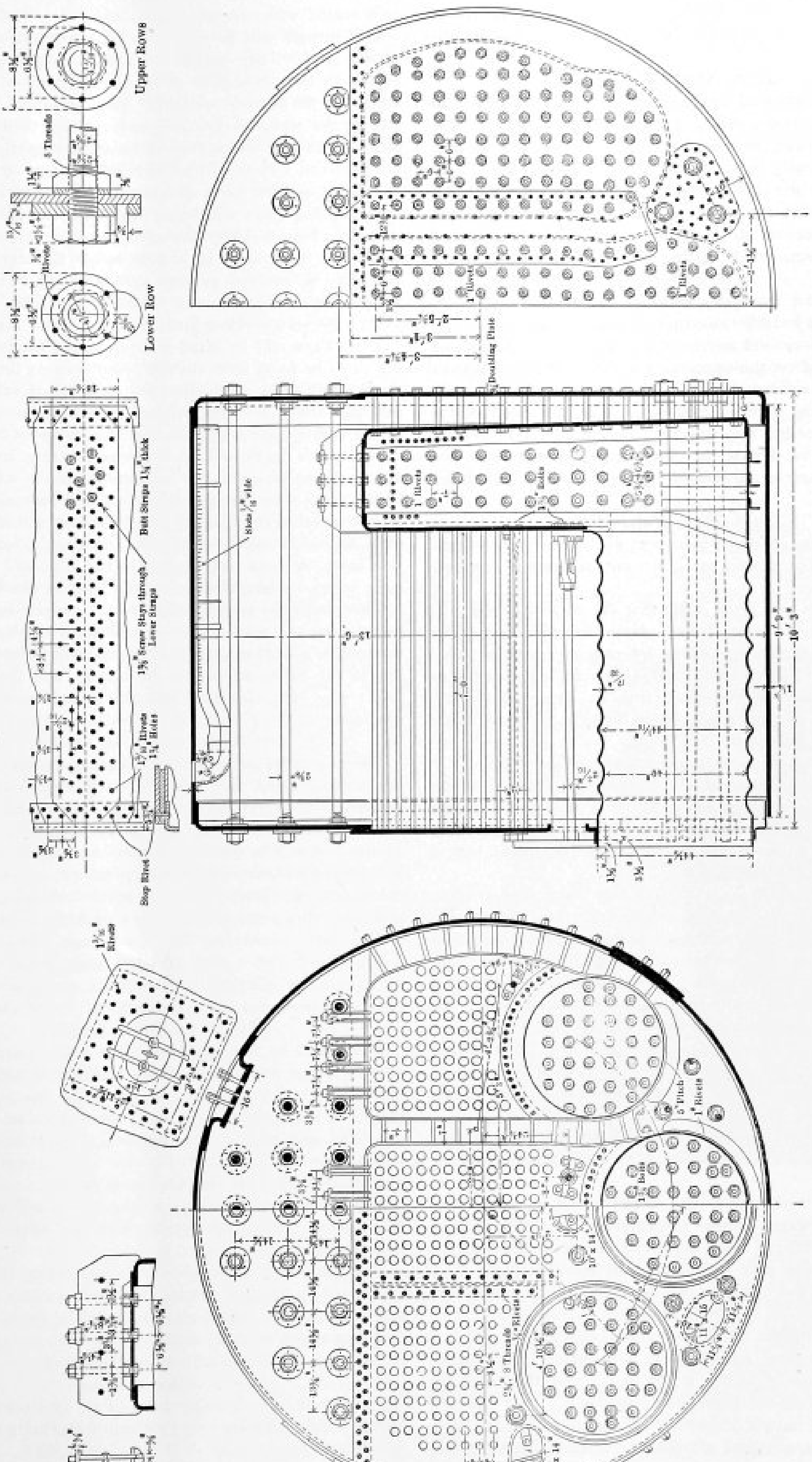
Boiler Attachments.

The boiler will have the following attachments of approved design, viz., one main steam stop valve, one auxiliary steam stop valve, one whistle-steam stop valve, one dry pipe, one main-feed check and stop valve with internal pipe, one auxiliary-feed check and stop valve with internal pipe, one surface blow valve with internal pipe and scum pan, one or more bottom blow valves with internal pipes, a twin-spring safety valve, one steam gage, one glass and one reflex water gage, both of the automatic self-closing type; four approved gagecocks, one sentinel valve, one salinometer pot, one or more draincocks, one aircock and zinc protectors, with baskets for catching pieces of disintegrating zinc.

All the external fittings on the boiler will be of composition, unless otherwise directed, and will be flanged and through-bolted, or attached in other approved manner.

All cocks, valves and pipes unless fitted on pads or in other approved manner will have spigots or nipples passing through the boiler plates.

All the internal pipes will be of brass or copper, as approved, and will not touch the plates anywhere, except where they connect with their external fittings. The internal feed



THREE-FURNACE SINGLE-ENDED SCOTCH BOILER, WITH DETAILS OF STAYS, CROWN BARS, RIVETING AND MANHOLE DOUBLING PLATES.

and blow pipes will be expanded in boiler shells to fit the nipples on their valves or will be secured in other approved manner, and will be supported where necessary and as directed.

Steam-Stop Valves.

There will be approved composition stop valves 6 inches in diameter for the main steam, 4 inches in diameter for the auxiliary steam, and 2 inches in diameter for the whistle steam, fitted to each boiler in an approved manner. These valves will close toward the boiler, and approved extension rods will be fitted to the hand wheels for the main and auxiliary steam-stop valves, so that they may be opened or closed from a location outside of the fire room space.

Dry Pipes.

The dry pipe for the boiler will be of copper, No. 14 U. S. S. G., and will be heavily tinned inside and outside.

The pipes will extend nearly the length of the boiler and will be perforated on the upper side with longitudinal slits or holes of such a number and size that the sum of their areas will equal the area of the steam pipe. The valve end of the pipe will be expanded into the main and auxiliary stop-valve nozzles, or will be secured in other approved manner. The pipes will be closed to the boilers, except for the slits or holes above mentioned.

Feed-Check Valves.

There will be an approved main and an auxiliary feed-check valve on the boiler, placed as shown on the general arrangement.

The valve cases will be so made that the bottom of the outlet nozzle shall be at least ½ inch above the valve seat. The valves will be assisted in closing by phosphor-bronze spiral springs. The valves will have hand wheels and approved gear where necessary for working them from the fire room floor.

There will be an approved stop valve between each check valve and the boiler.

Blow Valves, Blowpipes and Pumping-Out Pipes.

There will be an approved 1¼-inch surface blow valve on the boiler, located as directed. The valve will close against the boiler pressure. An internal pipe will lead from the valve to near the water line in the boiler and will be fitted with a scum pan.

There will be one or more approved 1½-inch bottom blow valves on each boiler, located as directed. The valves will close against the boiler pressure. Internal pipes will lead from the valves to near the bottom of the boiler, as required.

An approved 2-inch copper pipe will connect the bottom blow valves with an approved sea valve located where directed in the same compartment. These pipes will have 1¼-inch nozzles for the attachment of pipes from the surface blow valves, and also 2-inch nozzles for the attachment of the boiler pumping-out pipes. All joints will be flanged joints, as approved.

There will be a nozzle with a flanged valve on the sea valve, above mentioned, for the connection to the hose for wetting down ashes.

An approved 2-inch pipe will connect the bottom blow pipes to the salt-water suction manifold of the auxiliary feed pump, and so arranged with approved valves in the various pipes that the boiler may be pumped out when desired. The suction pipes for the injectors will be taken off the pumping-out pipes by means of approved branches, valves, etc.

Safety Valves on Boilers and Escape Pipe.

The boiler will have an approved twin-spring safety valve (two valves), each 3 inches in diameter, and they will be located as shown on the general arrangement.

Each valve will have a projecting lip and an adjustable ring for increasing the pressure on the valve when lifted, or an equivalent device for attaining the same result. They will be adjustable for pressure up to the test pressure. Gags will be furnished with each safety valve so that the valves may be held seated when testing the boilers.

The springs will be square in cross-section, of first quality spring steel. They will be of such a length as to allow the valves to lift one-eighth of their diameters when the valves are set at 180 pounds pressure. They will have spherical bearings at the ends, or they will be connected to the compression plates in such a manner as to insure a proper distribution of the pressure. They will be inclosed in cases so arranged that the steam will not come in contact with the springs.

The spring cases will be so fitted that the valves can be removed without slacking the springs. The valve stems will fit loosely in the valves, to bottom below the level of the seats, and will be secured so that the valve may be turned by a wrench or crossbar on top of the stem. The valves will be guided by wings below and in an approved manner above.

The valves will be fitted with approved mechanism for lifting them by hand from the fire room floor or the engine room, as directed. The mechanism for each set of valves will be so arranged that the valves will be lifted in succession. All joints in the lifting-gear mechanism will be composition bushed.

The outlet nozzle will be in the base casing, so that the joint at the escape pipe will not have to be broken when taking the valves out. The casings and valves will be made of composition, the valve spindles of rolled bronze, and the valve seats of solid nickel castings screwed into the top of the composition base. A drain pipe leading to the bilge will be attached to each safety-valve casing below the level of the valve seat.

There will be an approved 7-inch copper escape pipe, located abaft the smoke pipe, extending to the top, finished and secured in a neat manner. This pipe will have branches leading to the safety valves on the boilers, and the auxiliary exhaust pipe will also lead into the escape pipe, as elsewhere specified.

Steam Gages for Boiler.

There will be an approved steam gage for the boiler, located and secured in a conspicuous position on the fire room bulkhead, as directed, so as to be easily seen from the fire room floors. This gage will have dials 8½ inches in diameter and will be inclosed in polished brass cases. The gage will be graduated to 360 pounds pressure and so adjusted that the needle will stand vertical when indicating the working pressure; this point will also be plainly marked with red.

The valve connecting the steam-gage piping to the boiler will be fitted with a guarded valve stem and a detachable key or wrench for opening or closing the same; also with an approved opening for the attachment of a test gage.

Boiler Water Gage.

There will be one approved glass water gage and one approved reflex water gage, both of the automatic self-closing type, fitted to the boiler, as directed. Each gage will be placed in plain sight, near the front of the boiler. The shut-off cocks will have a clear opening of at least ½ inch in diameter, and will be packed cocks, with approved means for operating them from the fire room floor.

The blow-out connections will be valves and will have brass drain pipes leading to the bilge, with union joints, ½-inch iron-pipe size.

The glasses will be about 18 inches in exposed length. They will be ¾ inch outside diameter, will be surrounded by brass wire-mesh shields and protected by guards.

Reflex gages must be designed to fit the water-gage fittings, so that the two kinds will be interchangeable.

Gage Cocks.

There will be four gage cocks of an approved pattern fitted on the boiler, with approved means of operating them from the fire room floor.

Each cock will be independently attached to the boiler. The valve chamber will have two seats, the inner one formed in the casting, and the other movable, screwed into the casting and furnished with a handle. The valve will have two faces and will be closed by screwing down the movable seat and opened by the pressure in the boiler when the outside seat is slackened off. There will be a guide stem on each side of the valve, the valve and stem being turned from one piece of rolled manganese, phosphor, or Tobin bronze. The stem will be circular in section where it passes through the movable seat, and the outer end of stem will project ¾ inch beyond the movable seat and will be squared for a wrench. The inner end will be of triangular section. The opening of the valve will be at least ⅜ inch in diameter and the discharge from the chamber will be at least ¼ inch in diameter.

The gage cocks will be spaced about 4 to 5 inches apart, as directed, and each set will have a copper or brass drip pan and a ¾-inch brass or copper drain-pipe connection leading to the bilge.

Sentinel Valves.

The boiler will be fitted with an approved sentinel valve at the front end ½ square inch in area. It will have a sliding weight on a notched lever and will be graduated to 190 pounds pressure.

Salinometer Pots.

There will be approved salinometer pots, fitted with brass hydrometers and thermometers, connected to the boiler, as directed. They will be located in the fire room or where required.

Boiler Drain Cocks and Aircocks.

The boiler will have one or more approved drain cocks, placed so as to drain the boiler thoroughly.

The boiler will have at the highest point an approved ½-inch aircock.

Zinc Boiler Protection.

Zinc for the protection of the boiler will be held in baskets suspended from the stays, or as approved; these baskets will be made of wrought iron, perforated on the sides and solid on the bottom. The baskets in each boiler will contain sufficient rolled zinc to make the total quantity for the boiler not less than 100 pounds for each 15 square feet of grate surface, and the baskets will be distributed as directed. Each strap for supporting the baskets will be filed bright where it comes in contact with the stays, and the outside of the joint will be made water tight by approved cement.

Repairing a Boiler.

Temporary repairs on a boiler will often save considerable trouble and expense until permanent repairs can be made. The following is a job of this sort which proved successful:

The leak was in a seam of a butt-strap joint, and two 1-inch holes were drilled through the butt strap with a flat end drill, care being taken not to damage the shell itself. These holes were threaded to the bottom with gas taps, and were spaced twice the distance apart that they were from the extreme end of the leak.

Red lead putty was then prepared smooth as oil, free from grit and not too thick. Round iron rods were threaded to fit the holes already bored and a square end filed to take a wrench, the whole apparatus being termed a "putty pump."

One hole was half filled with putty and the threaded bar screwed down with the wrench; the operation was repeated with the other hole, and then with the holes alternately until no more putty could be squeezed in. Putty could be seen squeezed through around the seams and between the plates, and plugs were then screwed down hard to the taper threads and cut off flush. The boiler was left for a day or two to let the putty harden, and was then put into condition and used for several months. This method is not to be recommended for a permanent repair, but for an emergency job it will answer the purpose.—*American Machinist.*

A Peculiar Boiler Failure.

A plain cylindrical fire-tube boiler had been used in a saw-mill for about fifteen years and little or no attention was paid to the internal condition of the surfaces. The shell was made up of three plates and carried a dome in the middle of the central section. One day, without any apparent warning, the middle plate bagged down and the mill had to be shut down. The defective portion of the plate was then cut out and a large patch put on. In a week or so the patch bagged. Little or no sediment could be found on the surfaces either time.

A new and larger patch was put on, but the same thing occurred after the boiler had been under steam a few days. An entirely new plate was then put in the middle of the boiler to replace the defective one and it was thought that the trouble would be over, it having been assigned to the unequal expansion of the new and old metal when the patches failed. It was only a short time, however, until the new plate bagged directly under the drum in the same place that the trouble had been present before. No one has yet been able to determine the cause of this failure.—*Engineer.*

PERSONAL.

Mr. W. H. S. Bateman.

Mr. W. H. S. Bateman has severed his connection with the Lukens Iron & Steel Company, after fourteen years of service with them, and has now entered the employ of the Chicago Pneumatic Tool Company as their Southern representative at their Philadelphia offices, 819 Arcade building, and will hereafter look after this field for them.

MR. W. H. S. BATEMAN.

Mr. Bateman, who is secretary of the Associate Members of the American Boiler Manufacturers' Association, has a wide and favorable acquaintance throughout the field which he has covered. He has a close knowledge of the many kinds and uses of steel, and will bring to bear on his new line the results of his many years of successful experience in the trade.

The Hunslet Engine Company, Ltd., Leeds, England, have appointed as their sole London representatives Messrs. J. E. Lawler & Muirhead, 39 Lime street, E. C., London, England.

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - New York

Christopher St., Finsbury Square, London, E. C.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico........	$1.00	.10
Other countries in Postal Union..........	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

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 5,800 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

The Joint Convention.

That an industry as specialized as boiler making should have two distinct branches whose interests and methods differ sufficiently to cause the masters of the craft in the two branches to form separate associations for the education and advancement of boiler makers has seemed strange to outsiders. Certain members of these two organizations have realized this ever since the dual associations have existed, and for the last four years the men who stand foremost in the industry have sought earnestly to bring about the consolidation of the two associations, believing it to be for the best interests of all boiler makers that they should meet together and work together on common ground. Without reviewing the arguments for and against the amalgamation of the two associations which have been brought up and the obstacles which have been overcome, it is sufficient to say that this year the members of the Master Steam Boiler Makers' Association and of the International Railway Master Boiler Makers' Association will meet in a joint convention to form permanently one strong association of master boiler makers, a step which we sincerely believe will prove a decided benefit to boiler makers and the boiler making industry.

This convention will be held at Cleveland, Ohio, on May 21, 22 and 23, and a very interesting program is being prepared for discussion. The educational value of such a meeting cannot be over emphasized, and everyone who can possibly attend this convention will be well repaid for his effort. Not only will much benefit be derived from the valuable papers which will be presented before the convention, but the opportunity to meet with master boiler makers from all parts of the country and exchange ideas upon the thousand and one things which cannot possibly be discussed in a formal session of the convention, is of even greater value. The social part of the program will be given a due amount of attention, and everything will be done to make the 1907 joint convention the largest and most successful meeting of master boiler makers that has ever been held in this country.

Experimental Work.

Experimental work is usually carried on for one of two purposes; either by a scientific investigator for the purpose of research or by individuals or industrial concerns, for the purpose of applying some known law, theoretical or practical, to some marketable product, or to some process of manufacture. The technical schools, colleges and universities are responsible for a large amount of experimental work carried out in the former manner. Such work is almost certain to be performed in a systematic way, based upon correct assumptions and carried through to logical results, and much is contributed yearly to the fund of industrial knowledge from this source. On the other hand, much that might be applied in a useful manner is lost through a lack of practical insight in men who are interested merely in science. It is said that Lord Kelvin failed to recognize some of his own inventions when applied in a practical way in machinery. The distinguished scientist had deduced the laws and formulated the principles upon which every movement of the machine was based, and yet every detail of its mechanism had to be carefully explained to him before he recognized it. Experimental work, carried on by industrial concerns for the purpose of perfecting some product or process, is invariably performed with the utmost secrecy, and the public learns of it only through the resulting patents. Unlike purely scientific research, none of the mistakes or failures are recorded by which others may profit.

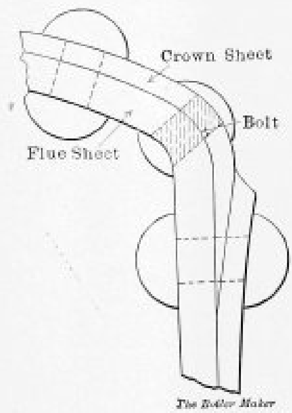
The results of scientific work carried on in a thorough and intelligent manner are usually given out in complete reports, whether they prove of much value or not. On the other hand, experiments in a small way are being carried on continually in large industrial plants by the foreman and men in charge of the work which never come to light, but which prove of inestimable value to the men who performed them. This happens in boiler making just as often as in any other branch of manufacturing. The variety and nature of the work make frequent demands upon the ingenuity of the workmen and foremen, which are usually met with a skill and judgment well worth telling about. An examination of the methods and rules for doing work in a score of different shops will often show that one man has a rule for doing a certain class of work which has always puzzled the workmen in another place. While such information has no market value it is kept more or less secret on account of the lack of means for making it known. Industrial associations and technical papers have supplied a means of giving others the benefit of such work. Often, however, a man fails to recognize the importance of the work which he has done or the fact that it might be of interest to others. A good workman likes to have a rule to go by, and if the results of any work can be expressed in the form of a rule which will apply in all cases, or in certain cases which are easily defined, it is sure to be of value to others.

COMMUNICATIONS

Bolt or Rivet?

EDITOR THE BOILER MAKER:

Answering a reader's question on page 25 of the January issue of THE BOILER MAKER as to whether a rivet or threaded bolt will make the better job in the corner of a flue sheet, as



shown in the accompanying sketch, will say that the threaded bolt well put in is by far the best method and most practical way to hold and keep such a corner tight.

T. C. BEST.

High-Speed Steel Rivet Dies

EDITOR THE BOILER MAKER:

I was very much interested in the reports of the different topics discussed at the convention held by the Master Steam Boilermakers Association in Chicago. I would like to add a little to the discussion on Topic No. 10 on the care of hydraulic riveting and flanging machines. I was not present at the convention, but read the report in your valuable paper; speaking on the life of rivet dies for the hydraulic riveters it was brought out that the most that could be got out of one pair of dies before going back to the tool room was about 4,000 rivets. When we used cast-steel rivet dies we had the same trouble. We would get about one day's work out of them; then they went to the tool room, were softened, turned up and retempered. The same process was gone through several times, then the steel was of no more use, the dies either broke in two or developed cracks and had to be consigned to the scrap heap. We usually ran three or four pairs of dies and cooled them off in water as they got hot.

We tried a pair of dies made from high-speed steel; they were very successful. We then had four pairs made. They have been working right along and are still in good condition. The four pairs have driven 133,500 rivets 5/8-inch diameter in 11-16-inch holes at fifty tons pressure; that is 33,375 rivets to each pair of dies; they are quite sharp and in good condition and are for round-head style rivets. I expect to get a total of 50,000 rivets out of them before they go back to the tool room. As soon as one pair of dies get hot they are taken out and laid where the air can cool them and another pair put in their place; thus with four pairs the machine works right along, as there is always a cold pair ready to work with. The steel we use is Edgar Allen high-speed steel, air hardening, made by the Edgar Allen Company, Sheffield, England.

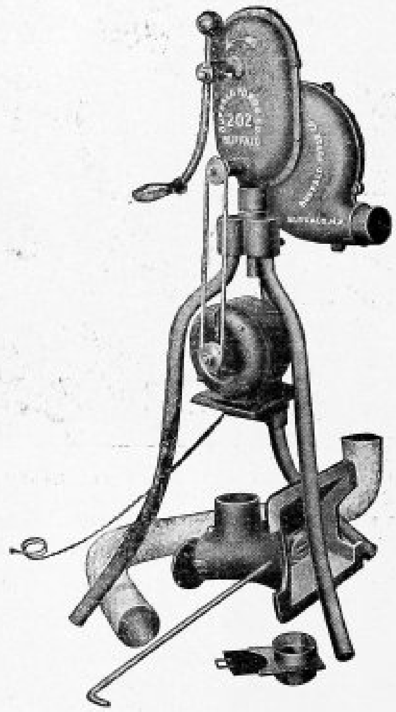
JAMES CROMBIE,
Foreman Boiler Maker,
Sawyer & Massey Company,
Hamilton, Ontario,
Canada.

ENGINEERING SPECIALTIES.

Buffalo Electric Blacksmith Blower.

Electric driven forge blowers are not what may be termed an innovation, for their use had become common in the larger forge shops, and small sizes have been economically employed by the smiths and horseshoers having a large amount of light work to handle, not because of convenience, but as money-savers. While the electric blower can be placed where most convenient, without regard to line shafts or other shop arrangements, it is found that its installation saves practically all the time of one helper, and only consumes power in direct proportion to the amount of air delivered.

For small shops on country circuits one complaint has formerly been that the supply of current could not be depended upon with absolute certainty, and that two blowers, one power-driven and one hand-driven, were necessary to insure against emergencies. To meet this demand the Buffalo Forge Com-



BUFFALO ELECTRIC BLOWER.

pany, of Buffalo, N. Y., have placed on the market within the last few months the Electric hand blower, being their well-known Buffalo No. 202, with an electric motor mounted on a small platform within the tripod legs of the machine. This places the motor in an out-of-the-way, yet readily accessible, position. The fan spindle is continued through the dust-proof oil case containing the gearing for the hand-drive and terminates in a small pulley which connects with the motor by means of a round belt.

The motors usually supplied are either 104-volt, 60-cycle, induction type for alternating current or for 110-volt, direct current, and are attachable by "lamp cord" to an ordinary 16-c.p. lamp socket as a source of power. If at any time it is desired to run the blower by hand, the belt is removed and the machine becomes at once the easy-running, powerful blast blower which has established the hand blower reputation of the Buffalo Forge Company.

The power for the hand drive passes through only two sets of helical and spur cut gears finished on special machines and running in an oil bath with the attendant minimum loss by friction. All bearings are bored and reamed in the solid metal, no liners being used. All the machine work is done on jigs, and the parts are interchangeable. The outlet of the fan casing may be turned at any angle desired, and the gear and fan case are also adjustable as to height. The blower is furnished with blast piping, air gate and the Buffalo side and center-blast tuyere shown in the cut.

The application of the electric-driven hand blower is not confined to forge fires, however, as it is suitable for use in systems for driving out smoke or fumes through piping where exhaust fans are not suitable, furnishing air at moderate pressures up to three or four ounces through short piping systems, etc. A feature of the outfit is the low cost, as well as the small weight and consequent freight charges.

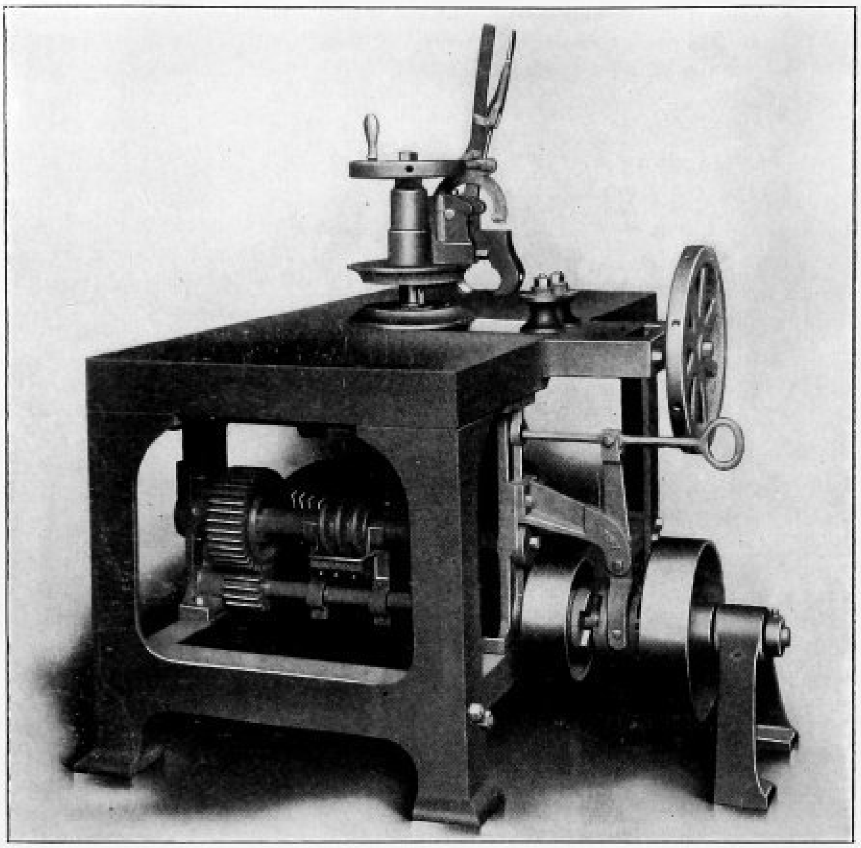
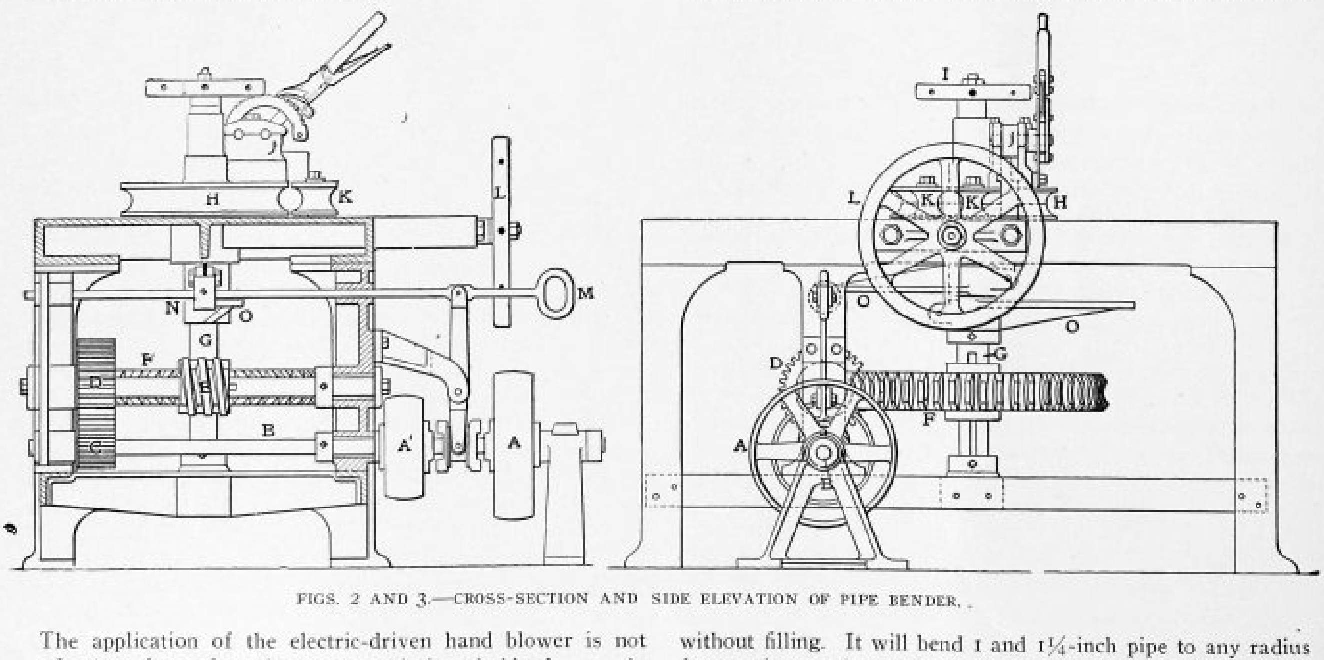


FIG. 1.—AN AUTOMATIC PIPE-BENDING MACHINE.

An Automatic Pipe-Bending Machine.

Fig. 1 is a general view of a machine designed to bend pipe into various shapes, such as U and S bends, return coils, etc., without filling. It will bend 1 and 1¼-inch pipe to any radius from 2½ to 12 inches; 1½-inch pipe from 3 to 12 inches radius; 2-inch pipe from 4 to 12 inches radius; 2½-inch pipe from 6 to 12 inches radius.



FIGS. 2 AND 3.—CROSS-SECTION AND SIDE ELEVATION OF PIPE BENDER.

The table is 61 by 32 inches, supported, as shown, on four legs, having braces between them which support the main driving and worm shafts. Between the braces is a bridge piece which supports the vertical shaft carrying the worm gear near

shaft engages the worm wheel *F*, mounted on the vertical shaft *G*. The forming roller *H* is in two parts. The upper part of *H* is splined to the shaft *G*, and may be raised and lowered by means of a screw, actuated by the hand wheel *I*.

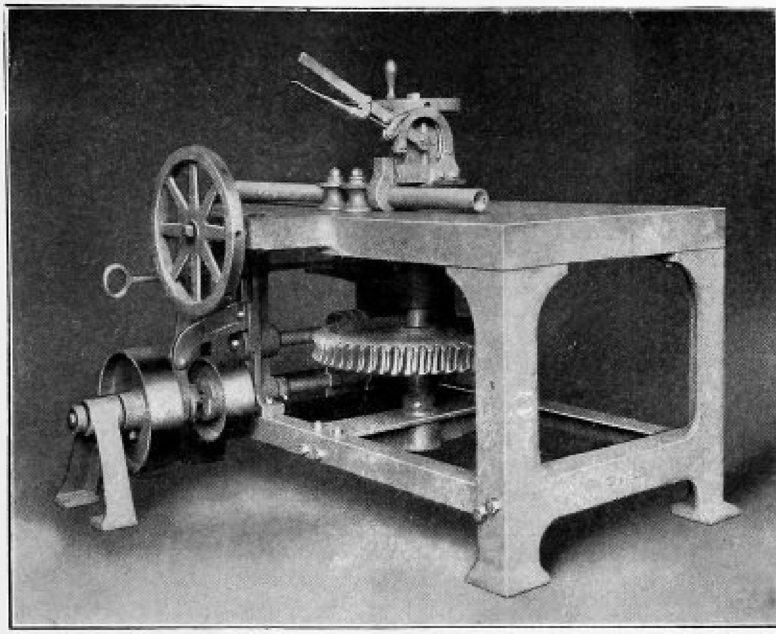


Fig. 4.—Pipe Gripped Ready for Bending.

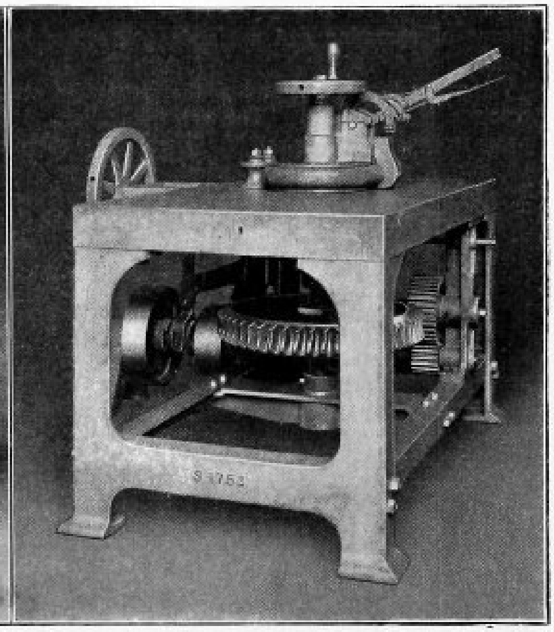


Fig. 5.—The Completed Bend.

its lower end. The vertical shaft projects through the table and carries at its upper end the forming roll and clamping device for holding the pipe while being bent. To the right, in Fig. 1, are shown the two pressure rolls on top of the table.

The clamp *J* is secured to the forming roll *H* and revolves with it. The clamp *J* is more fully shown in Fig. 4. The pressure rollers, which bear against the pipe are shown at *K*. They are attached to a slide actuated by the hand wheel *L*.

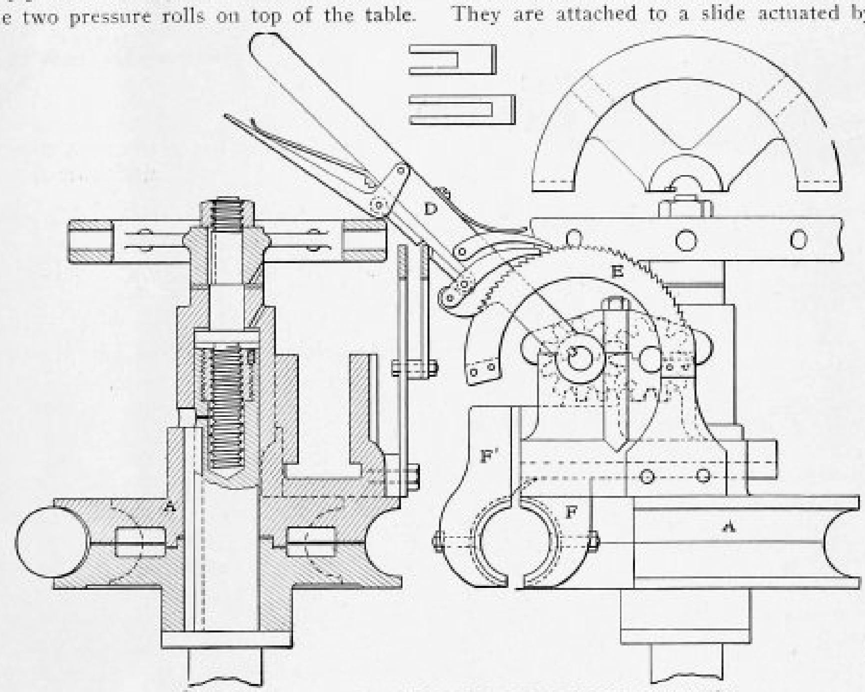


Fig. 6.—Details of the Automatic Pipe-Bending Machine.

These are advanced or withdrawn by means of a screw, operated by the hand wheel shown to the right.

Figs. 2 and 3 show the machine in section and side elevation. The driving pulley *A* and the small quick-return pulley *A'* are mounted on the driving shaft *B*, with a clutch between them. At the other end of *B* is the pinion *C*, which engages the spur gear *D* mounted on the worm shaft. The worm *E* on this

On the vertical shaft *G* are two levers *O*. These are adjustable and control the amount of bend given to the pipe, for when they come in contact with the collar *N* on the shifter rod *M*, the clutch is thrown out of engagement with the pulley *A* or *A'*, whichever happens to be in engagement at the time. In this way the traverse of the forming roll may be set so as to produce uniform bends in any quantity.

Fig. 6 shows the details of the forming roll to the left, and the clamping mechanism to the right. The line cut shows plainly how the upper half *A* of the forming roll is raised and lowered by the screw. The pipe clamps *F* and *F'* are opened and closed by the two racks operated by the two pinions as shown. The lever *D* and ratchet quadrant *E* provide an easy means of operating and a simple and secure lock for the clamp.

Referring to Figs. 2 and 3, the method of operating the machine is as follows: The pressure rollers *K* are drawn away from the forming roll *H*. The clamping lever is thrown up into a vertical position, which opens the pipe clamp *J*. The upper part of the forming roll *H* is raised about ½ inch. This permits the pipe to be readily entered in the machine. The pipe is entered and located at the proper position for the bend. The upper half of the forming roller *H* is then screwed down tight; the lever of the clamp *J* is pulled forward so that the clamp grasps the pipe; the pressure rollers *K* are forced against the pipe and the machine is started. The tripping arms *O* having been set at the desired points, the machine runs till the trip *N* operates, throws the clutch out and the machine stops.

This machine is built by the Stoever Foundry & Manufacturing Company, Myerstown, Lebanon County, Pa.

National Steel Tube Cleaner.

There is probably no tool used in the maintenance of boilers which has received more attention by experimenters and inventors than the boiler tube cleaner. One of the latest cleaners to be placed on the market, for which great success is claimed, is herewith illustrated.

The salient feature of the National steel tube cleaner is that each blade acts independently of the others and is so

THE NATIONAL STEEL TUBE CLEANER.

spring-like in nature that it conforms very snugly to the surface which is to be cleaned. It can be forced through the tube with very little effort, and each plate removes the particles of sediment or scale within the pipe. Another advantage claimed for this cleaner is that it can be adjusted to fit various sizes of pipe, and if one or more of its blades become broken by rough usage or wear, they can be readily repaired at nominal expense.

The National steel tube cleaner is manufactured by the H. W. Johns-Manville Company, whose factories are situated at Brooklyn, N. Y., and Milwaukee, Wis. The company, however, has branches in all the large cities.

The Little Giant "Corner Drill."

The Chicago Pneumatic Tool Company, of Chicago, Ill., now have ready for the market a new "Little Giant" drill for corner work. From past experience in air-tool practice, this company feels justified in stating that this drill surpasses any other drill yet devised for drilling in close quarters and in corners particularly, as the machine was designed especially for work of the latter class. Parts for their No. 4 Little Giant drill interchange with the new drill mentioned, thus insuring quick repairs. As seen from the illustration, the general design of the drill is neat and compact.

This new tool weighs but 35 pounds and is capable of drilling a 1½-inch hole, and in emergency cases will drive a 2-inch twist drill with very satisfactory results. The spindle speed when running light is 150 revolutions per minute; under load with 80 pounds air pressure it is 100 revolutions per minute.

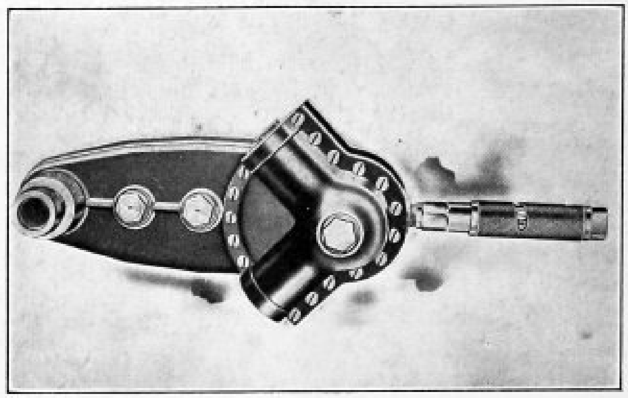


FIG. 1.—GENERAL APPEARANCE OF THE "CORNER DRILL."

The distance from the end of the socket to the end of the feed screw when run down is 5⅞ inches. The length of the feed is 2 inches. The distance from the center of the spindle to the outside of the housing is 1 5-16 inches.

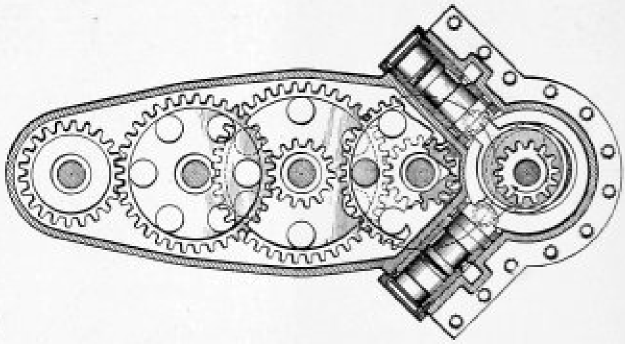


FIG. 2.—SECTION OF THE DRILL SHOWING THE DRIVING MECHANISM.

The drill is very powerful, weight considered, and a steady and constant spindle movement is insured, due to the fact that the spindle is driven by gears instead of by the ratchet principle.

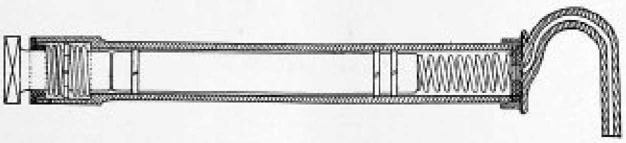
An Improved Holding Up Appliance for Riveting.

In the ordinary rivet holding up appliances provided with anvil pistons, the front part of the holder or sheath carrying the anvil piston also forms the pressing head or knob, so that the recoil is transmitted through the holder to the anvil piston. With this known arrangement a springing away of the holder at each blow is unavoidable, as the spring action of the anvil piston only absorbs a small part of the shock, the remainder being transmitted to the workman holding the holder up.

The object of the tool herewith illustrated is to give increased spring action within the holder and to minimize the shock communicated to the workman. This is accomplished as follows:

A separate pressure head is elastically inserted in front of the anvil piston in the holder, so that when riveting, the blow on this separate head is absorbed or received by the striker piston arranged behind it, whilst the holder itself experiences less shock from the blow.

The holding up appliance, which is provided with a rectangular head, is mounted by means of a rod in a cylindrical sheath or holder, and is surrounded by spiral springs acting in opposite directions, which springs are separated by an intermediate divided ring. In the holder, which extends to the rear, is situated an anvil piston, which on its ends is provided with piston rings as packing in the holder. The front of the anvil piston directly encounters the rear rebounding surface of the rod of the pressure head. The rear end of the anvil piston presses against a spiral spring, or against a compressed air



IMPROVED PNEUMATIC HOLDER-ON.

cushion, in communication with a compressed air passage arranged in the handle.

In riveting, recoil blows communicated to the pressure head, which is elastically mounted by means of the spring surrounding its rod, are absorbed by the anvil piston and transmitted to the rear spiral spring, thereby the holding up appliance remains in position, whilst the anvil piston makes a corresponding backward or recoil movement, and then is again moved forward by the action of the spring.

The patent rights for this tool are held by G. Biehl, Copenhagen, Denmark.

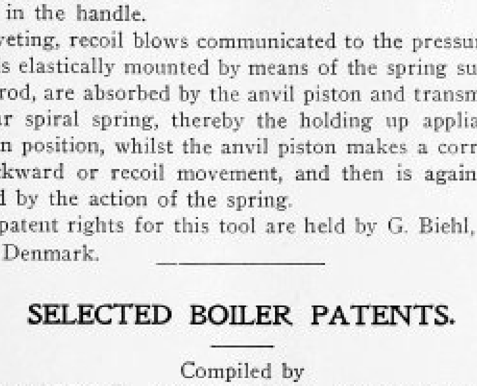
SELECTED BOILER PATENTS.

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

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

833,642. HEAT DIFFUSER FOR STEAM BOILERS. Alfred Smallwood, London, England.

Claim.—A means for generating and diffusing heat in connection with steam boilers comprising a furnace tube, a furnace formed within and adjoining the front end thereof, an inner tube of mineral material capable of becoming incandes-



cent centrally located within the furnace tube, supporting divisions to maintain the inner tube correctly positioned within the furnace tube and to form the space between the inner and furnace tubes into separate flues, means for the passage of the gases from the inner tube at the opposite end thereof to the furnace into one of said flues, and other means for the passage of the gases from said flue into the other flue or flues at the opposite end thereof to the first-mentioned means. Four claims.

832,785. JACKET FOR STEAM BOILERS. Jacob Fischer, Swanton, Ohio.

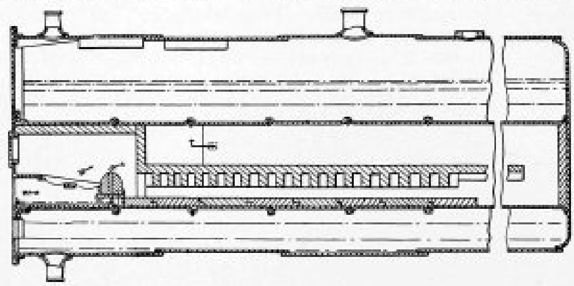
Claim.—A jacket for steam boilers, comprising a heat-insulating inner covering and a metallic outer covering arranged in spaced concentric relation thereto, longitudinal separating strips of insulating material interposed between said covering and arranged in spaced relation to form air spaces, said outer covering being formed with a plurality of annular sections having a peripheral alignment throughout the lineal extent of said outer covering, the meeting ends of said sections being severally secured to the corresponding separating strips and a series of retaining bands severally surrounding the respective sections of the outer covering. Two claims.

833,581. BOILER FURNACE. Ernest Desiré Cousin, Paris, France.

Claim.—A smoke-consuming boiler furnace comprising in combination an upper grate consisting of tubes, a lower grate consisting of fire-bars, transverse headers into which lead the tubes at their respective ends, a vertical separator, a union connecting the header to the separator, a wide conduit connecting the header to the separator, a water-pipe of very small diameter extending from the separator to a point below the water-level of the boiler, and a steam-pipe of small diameter extending from the separator to the steam space of the boiler. Three claims.

833,639. MEANS FOR GENERATING AND APPLYING HEAT FOR STEAM BOILERS, FURNACES, ETC. Alfred Smallwood, London, assignor to the Incandescent Heat Company, Ltd., London, England.

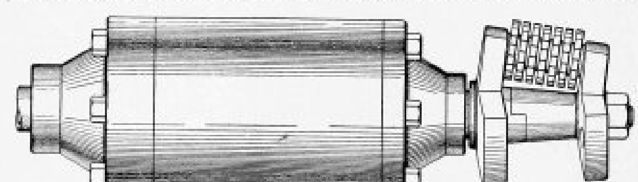
Claim.—The hereinbefore-described construction comprising a fire chamber, a shallow combustion chamber in rear of and in the same horizontal plane as the fire chamber and in communication therewith, a comparatively shallow heat chamber



above the combustion chamber with a refractory partition between them capable of becoming incandescent, and refractory obstructions capable of becoming incandescent projecting prom the partition into the combustion chamber to retard the circulation of the gases through the combustion chamber and mix and ignite them while retarded therein, and means of communication between the combustion and heat chambers at the end thereof opposite to the fire chamber. Two claims.

833,703. TUBE-CLEANING APPARATUS. Herman Van Ormer, Hartford, Conn., assignor, by direct and mesne assignments, to Liberty Manufacturing Company, of Pittsburg, Pa.

Claim.—The combination in the cutter head of a tube-cleaning apparatus, of a pair of interlocking heads, having in their



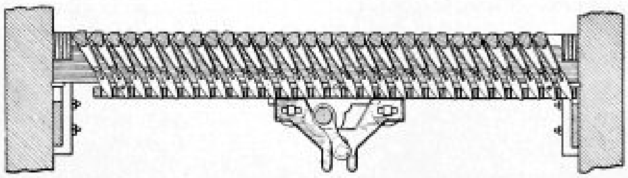
inner faces radial grooves forming seats for inclosing the ends of the cutter shaft, a cutter shaft whose ends are loosely mounted in said seats, and entirely surrounded and inclosed thereby, means for mounting and driving the said heads, and a plurality of cutters loosely mounted for independent rotation on the said shaft. Four claims.

833,845. GRATE-BAR. Peter McNaughton, Charlotte, Mich.

Claim.—In a grate-bar, a supporting device comprising end bearings having vertical depending portions and with a bar extending between the lower terminals of said depending portions and arranged side by side in the fire-chamber, fuel supports consisting of plates arranged end to end upon said bar with their upper faces flush with each other and also flush with the end bearings and each plate provided with spaced lateral wings reversely inclined to the longitudinal planes of the plates, said inclined wings of one bar extending to the inclined wings of the next bar, whereby the inclined faces extend constantly away from the line of movement of the implements employed in manipulating the fuel upon the grate-bars, and means for detachably coupling said plates to said bar. One claim.

833,934. ROCKING GRATE. Thomas E. Martin, Buffalo, N. Y.

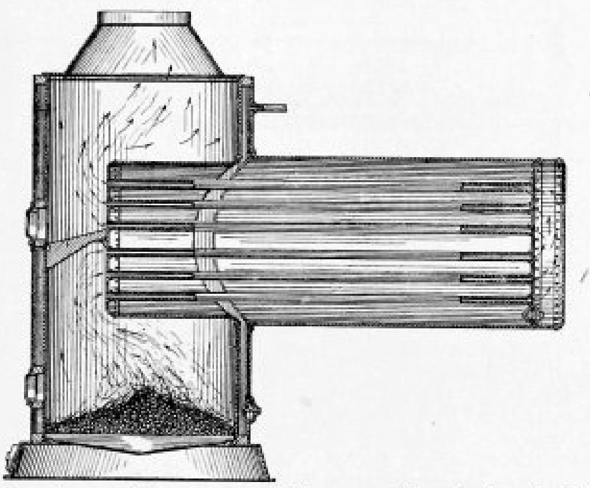
Claim.—A grate comprising rocking grate-bars each provided with a depending leg, a connecting bar movably engaging said legs, a rock-shaft below the grate-bars and extending



parallel therewith, a bracket adjustably secured to said connecting bar and embracing said shaft, said shaft being provided with a crank engaging said bracket, and the inner faces of the bracket being so spaced in relation to the shaft that they are adapted to alternately engage the same to limit the movement of the grate-bars. Four claims.

834,131. STEAM BOILER. Frederick B. Hibbard, Philadelphia, Pa.

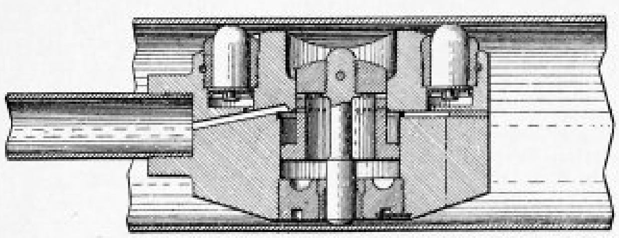
Claim.—In a steam boiler, in combination, an internally-fired vertical member and a horizontal member, the latter of which is provided with two sets of flues and one end of which



projects into and forms part of the top of the fire-box in the vertical member, and a wall or partition extending from the inwardly projecting end of said horizontal member from points between said series to the inner sides of said vertical member completing the top of the fire-box and separating the outgoing and incoming flues in said horizontal member, the portion of said horizontal member below said partition projecting into said fire-box. Three claims.

834,306. AUTOMATIC BOILER TUBE CLEANER. Albert F. Krause, Buffalo, assignor of one-half to Charles C. Ladd, Buffalo, N. Y.

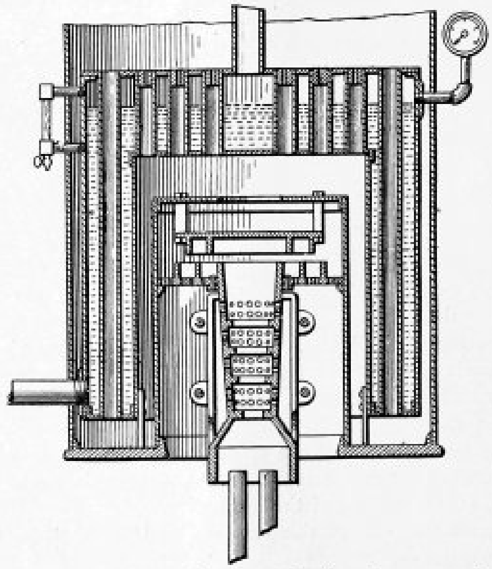
Claim.—In a boiler cleaner, the combination of a casing provided with a transverse fluid chamber having an end open-



ing which extends through the side of the casing and forms a lateral exhaust port for the motive fluid, a piston arranged in said chamber, means for controlling the supply of the motive fluid to opposite sides of the piston, and a scale-loosener actuated by the piston and arranged to pass through the side of the casing. Nine claims.

834,221. STEAM BOILER. Virgil W. Blanchard, New York, N. Y.

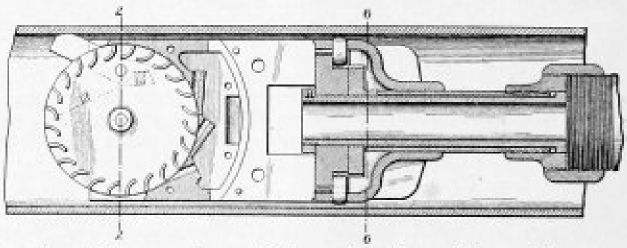
Claim.—In a boiler, the combination of a gas-burning apparatus, an inverted cup-shaped boiler placed over the gas-



burning apparatus, a combustion chamber between the upper end of said burner and the crown sheet of said boiler, descending flues between the said burner and the surrounding annular leg of the boiler, a casing, and flues between the outer walls of the boiler and the casing. Five claims.

834,459. STEAM BOILER TUBE AND FLUE SCRAPER OR CLEANER. Cyrus S. Dean, Buffalo, assignor to Albert D. Jamieson, Buffalo, N. Y.

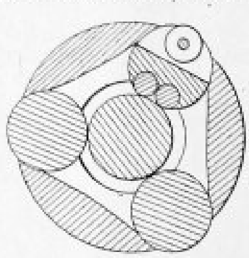
Claim.—In a tube or flue scraper or cleaner, the combination with a shell or casing, of a rotary turbine wheel carried



by the shell or casing with its axis of rotation positioned so as to lie crosswise of the cleaner-head, a cleaner or cutter rotated in the same general direction as that of the plane of rotation of said turbine wheel, and means for automatically turning or rotating the turbine wheel and cutter sidewise in addition to its own rotation. Thirteen claims.

835,556. BOILER-FLUE EXPANDER ATTACHMENT. David M. Remson and Andrew C. Remson, Talladega, Ala.

Claim.—The combination of a tool stock having a longitudinal opening therethrough and provided with a series of slots having communication with the opening, a block adapted to be inserted into one of the slots, a cutting disk mounted upon the outer face of the block, a series of anti-friction



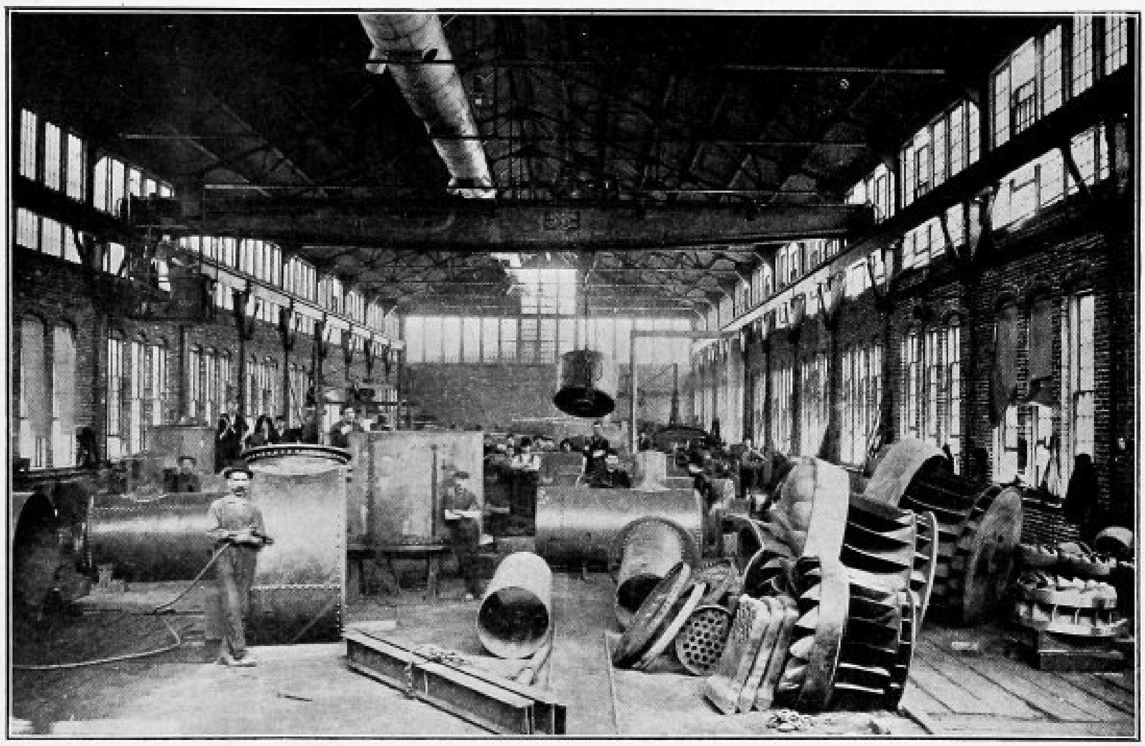
rollers located in a recess in the inner face of the block, said recess being formed with depressions which serve as bearings for the anti-friction rollers, and a spindle passing through the longitudinal opening through the tool stock and adapted to engage with the before-mentioned anti-friction rollers upon the block. Two claims.

THE BOILER MAKER

VOL. VII — MARCH, 1907 — No. 3

THE BOILER SHOP OF JAMES LEFFEL & COMPANY.

The new boiler shop of James Leffel & Company, Springfield, Ohio, is one of the most modern boiler making plants, both in construction and equipment, in the United States. The shop, which is 220 feet long by 60 feet wide, is built entirely of brick and steel. The vertical columns of the steel frame are spaced 18 feet apart, and support in addition to the roof tresses the horizontal girders upon which a 15-ton electric traveling crane is operated. As can be seen from the accompanying photographs, the shop is exceptionally roomy and light. There are three large windows between each of the steel columns, and the upper part of the walls is almost entirely of glass. The shop is heated by a hot-blast fan system installed by the Buffalo Forge Company, Buffalo, N. Y.



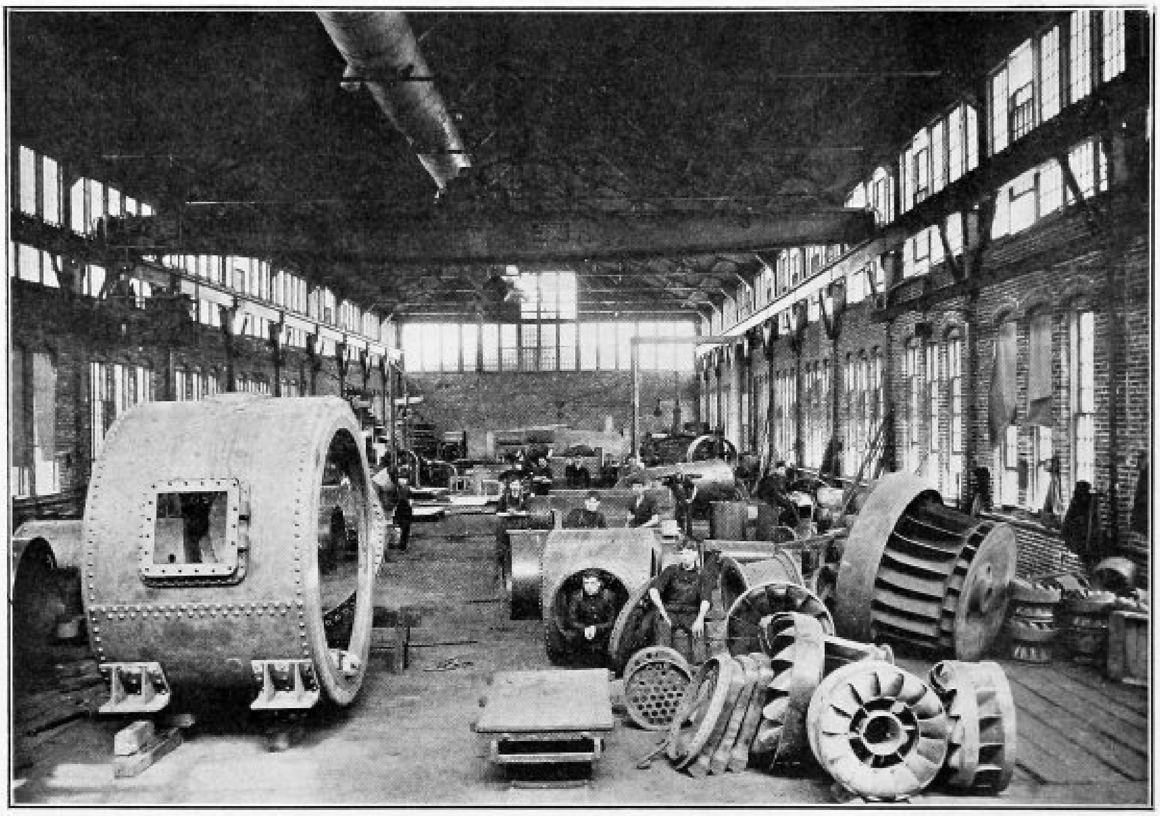
VIEW IN BOILER SHOP OF JAMES LEFFEL & CO., LOOKING NORTH.

Along the east side of the shop just outside the wall is a side track from the Chicago, Cleveland, Cincinnati & St. Louis Railroad, from which material is unloaded and loaded by means of a crane through a large door in the east wall of the building, about one-third of the length of the shop from the north end. Within the shop the material is handled by the 15-ton Northern Engineering Company crane already mentioned, which spans the entire width and travels the entire length of the shop. Individual machines are served by light jib cranes and hoists. Also trucks operated on shop tracks are used for conveying the material about the floor.

All of the machines in the shop are electrically driven, each by a special motor. In the northeast corner of the shop near the large door through which material is received and shipped is a motor-driven Lennox rotary splitting shear, which has a capacity for shearing plate up to ½ inch in thickness. Beyond the splitting shears is a No. 24 motor-driven Hilles & Jones punch, which has a 52-inch gap and is capable of punching 4-inch holes in ½-inch plate. In the southeast corner is a set of 10-foot motor-driven Hilles & Jones bending rolls, capable of bending plate up to an inch in thickness. On the opposite side of the shop is a smaller set of Hilles & Jones rolls for bending sheet iron. These are 4 feet long and have a capacity of ¼-inch plate. On the western side of the shop are also located a No. 3 motor-driven Hilles & Jones punch, having a 36-inch gap, with a capacity of punching a 6-inch hole in ½-inch plate; a No. 4 Wangler motor-driven bevel shear, having a capacity of ¾-inch plate, and a No. 34 Hilles & Jones horizontal combined punch and bulldozer. The bulldozer has a capacity for straightening 15-inch beams and steel shaft 9 inches in diameter.

In the southwest corner of the shop is a testing floor with ample facilities to provide for the testing of all boilers under hydrostatic pressure. Here the final tests are made before the boilers leave the shops. In addition to the above-mentioned tools the shop is provided with a full equipment of gas forges and rivet-heating furnaces and also a complete equipment for pneumatic riveting, calking and chipping.

In Fig. 2 can be seen, suspended from the overhead electric crane, the partly finished case of a penstock for a turbine water-wheel. In this shop all the penstock and pipe work for water-wheel installation, which is a specialty of this company, is done.



VIEW IN LEFFEL BOILER SHOP, SHOWING PENSTOCK CASINGS.

Effect of Water on The Life of Boilers.

BY A. S. ATKINSON.

The prolongation of the life of a steam boiler is a matter of deep concern to the manufacturers as well as to the users, and the former should be vitally interested in devices intended to preserve the boiler from interior corrosion and general depreciation. The question of the formation of scale in the boiler has provoked endless discussion and interest in the trade, and in the more refined practice of steam production of to-day the efficiency of the boiler often determines the profits or losses of a plant. When the boiler maker has finished his work the life of the boiler and its efficiency are guaranteed only under certain conditions of proper usage and care; but there are always indeterminate questions which affect the production of steam, and which cannot enter into previous calculations.

One of the most important of these is the quality of the feed water employed for the generation of the steam. The dirt and sediment in feed water may be in sufficient quantities to cause trouble with the boiler within a short time unless some device is used for cleansing regularly, or the water is purified by artificial methods. In this country we have the greatest variety of feed water, ranging from almost pure to thick, muddy water heavily charged with scale-forming ingredients. The location of a steam plant on land is therefore of considerable importance in determining the life of a boiler, unless modern methods are used for purifying the water or elaborate devices are in constant use for keeping down the scale.

The loss of heat and efficiency caused by boiler incrustation has been variously estimated by engineers, and details of scale thickness or density are always essential to the proper calculation of the cost of steam production. It has been commonly accepted by many engineers that a scale of sulphate of lime one-sixteenth of an inch thick will reduce the efficiency nearly 15 percent. But the conductivity of boiler scale unquestionably differs very much according to its general composition. The carbonates of lime and magnesia cause a good deal of trouble with heaters and boilers, and they form a scale inside which tends to thicken and retard the efficiency of the plant; but they are not nearly so injurious and wasteful in steam practice as the sulphates and other soluble compounds of lime and magnesia.

A well-designed boiler with 3-32 of an inch of scale will commonly give as good efficiency as a clean boiler that has not been so carefully designed and made, and it is therefore important that the character of the boiler itself should be determined before any trouble is first attributed to scale. The difference between a well designed and a poorly-designed boiler is as wide as the difference in the general construction of any other part of a steam plant. In a good many experiments made to test the relative effect of scale in producing steam, the fatal error has been made in taking two boilers not designed and made exactly alike. Such tests are practically worthless. It is impossible to ascertain the true results in any other way. A good many engineers will assert that the amount of loss of heat due to scale deposit is often overestimated. This is sometimes confusing, for the simple reason that the character of the boilers used is not taken into consideration, nor the nature of the deposits carefully ascertained. A soft and porous scale may cause comparatively little trouble until it gets quite thick. The loss depends more upon the kind of scale and its density than upon its relative thickness.

When all such data are taken into consideration it will be found that the loss of efficiency of a boiler is greatly affected by scale. It is difficult to put into dollars and cents the exact loss from this trouble, but the loss is not always solely in the fuel pile. It is often in the depreciation of the boiler itself. The constant forming of scale in the boiler and its periodical or continuous removal by mechanical cleaners, cannot but have an important effect upon the general life of the boiler. The weakening tendency may be due to strains imposed upon the boiler by the mechanical cleaners, and also to the harder working of the boiler necessary to secure a given amount of steam when coated inside with a thick scale of sulphates.

One other effect of impure feed water upon the boilers should be noted. In the coal and iron regions, especially in Pennsylvania and Ohio, the river and pond waters contain frequently a good deal of free sulphuric acid and acid iron salts. The waters of the Monongahela and Youghiogheny Rivers are particularly heavily impregnated with these acids, and steam plants which draw their feed water from them have experienced a great deal of trouble and expense. The water in coal-producing regions, which has been used for washing coal preparatory to coke production is also peculiarly subject to acidity. Such feed water is injurious to boilers through its corrosive effect. Employed constantly without any attempt at purification, the water greatly affects the life of the boiler through interior corrosion. Weakness appears early, and the boiler, while not affected by scale-forming deposits, depreciates rapidly and is soon worn out. There is another class of water found in many of the Southern States which carries great quantities of corrosive vegetable acids. These waters are commonly drawn from peaty districts or marshes and low lands where peat-forming materials have accumulated. The vegetable acids are not so corrosive in effect as the acid iron salts or the free sulphuric acid, but they are destructive enough to cause a good deal of loss and trouble. Even well waters containing magnesium chloride are corrosive in their action, and they sometimes cause loss by weakening the boilers. Where such well waters carry also an excess of calcium carbonate the corrosive effects of the magnesium chloride are practically neutralized and the danger is not of so great moment.

It is natural that in drawing feed water from so many different sources, the question of water upon the life of boilers should be more generally agitated than ever before, and that considerable investments should be made in water-softening and purifying plants. The extent to which this work has been carried in recent years is an indication of the efforts being made to reduce the cost of producing steam and to increase and maintain the efficiency of the boilers.

The mechanical methods for removing sediment from feed water are quite numerous, and their general effects are good. In a great many parts of the country they are essential for success in combination with chemical treatment of the water, and in other sections where the water is comparatively free from scale-forming materials, they answer all necessary purposes. These mechanical methods include feed-water heaters, scum catchers and blow-off cocks. The well-designed feed-water heater will remove carbonate of lime when not carried in excess. They are operated successfully in many cases in combination with scum catchers and blow-off cocks. They do not answer the purpose, however, where the sulphates and carbonates are in large quantities, or where acid iron salts or other corrosive and scale-forming ingredients predominate. In regions where the acids and scale deposits are numerous in the water, the feed-water heaters are affected by the water almost as much as the boilers, and unless they are constantly cleaned and kept in a perfect state of repair they perform little good service. Both pressure and temperature of the feed water have a modifying effect upon the foreign substances in water, and they contribute toward more or less rapid precipitation of the scale-forming ingredients. Preheating the feed water has thus performed excellent work in the past, and the feed-water heaters worked in combination with chemical purification plants are of great service.

The easiest and most efficient method of prolonging the life of the boilers by removing dangerous elements from the feed water before it enters the boiler is by chemical reaction. Most of the large railroads have purifying plants connected with their central stations, in which chemicals are used for precipitating the scale-forming materials in combination with mechanical appliances for eliminating the sludge. The saving in fuel and in the life of the boilers has more than proved profitable in such cases. The saving of the life of the boiler by means of these chemical purifying plants may be gathered from the reports of some of the large companies. One claims a saving of 75 percent in boiler repairs, due to the purification of moderately hard water by chemical reaction and precipitation, and another indicates a saving of $780 per year on an 800-H. P. plant as the result of chemically eliminating scale-forming ingredients before the water enters the boilers. A third company using the waters of Lake Michigan, which is classed as fair boiler water, but which, nevertheless, contains 12.16 parts of scale-forming solids per 100,000, effected an economy of $4,950 per year through the purification of the water, and a Chicago ice-making factory found that it required 16.63 percent less fuel to make a ton of block ice than was consumed before the feed water was softened and purified chemically.

As the life of boilers has been steadily prolonged in recent years, both by these improved methods of manufacture and by the mechanical and chemical means of eliminating from the feed water injurious ingredients, engineers have made the practice pretty general throughout this country. The very simplicity of the chemical methods recommends their use. The application of soda ash to the feed water and the regular blowing off of the sludge, practically adds many years of usefulness to the boiler. It is of such economic importance that there is hardly any excuse for not using this method for ordinary feed water that contains no particularly complex composition. The application of 0.02 pound of soda ash to each thousand gallons of water will cause each grain of calcium carbonate or magnesium carbonate contained in the water to change to carbonates, and in this form they will be precipitated. In their original crystalline form the solids will adhere to the sides of the boiler and gradually form a dense incrustation, but in the form of the carbonates they are harmless and can easily be blown out.

Similar action takes place when calcium sulphate is carried by the water, but in this case more soda ash is needed. About 0.10 pound is required to remove every grain of this mineral element from each thousand gallons; for magnesium sulphate 0.13 pound of soda ash is required, while magnesium chloride demands 0.16 pound for its elimination. But this amount is relatively unimportant when we take into consideration the low cost of soda ash, and so far as the cost of the chemical agent is concerned the expense of purifying the hardest water for boiler purposes is very small. In the direct introduction of soda ash in the feed water, it is necessary to blow off the precipitated sludge often, but even that is not always sufficient. In spite of this some of the sludge will remain in the bottom of the boiler, and its accumulation there, while not directly injurious, produces trouble. The boiler must consequently be cleaned quite often to eliminate every part of the soft sludge.

It is quite evident then that the simple direct treatment of feed water with soda ash performs a great service in many cases, but that it has its limitations which should be recognized by the engineer. For instance, when the scale-forming ingredients are present in large quantities so much soda ash must be introduced in the water that foaming results. This interferes with the proper precipitation of the soft sludge, and, as a result, a good deal of the incrusting solids fail to be acted upon by the soda. A few of them are left in the water to adhere to the sides of the boiler. It may therefore be deduced that the direct introduction of soda ash into the water, when the latter is only moderately hard, softens and purifies it, but when the water is very hard and carries a great many scale-forming ingredients, the direct use of soda ash does not suffice.

The introduction of the soda ash or phosphate of soda, as some use in water-storage tanks, so that the sedimentation can take place before the boiler is reached, is designed to overcome some of the difficulties experienced in purifying very hard water. The storage tank is thus utilized for chemical reaction and sedimentation. In such cases it is necessary to feed the soda ash in proper proportions either automatically or at regular intervals, and then have a floating draw-off and a dump valve in the bottom of the tank for removing the accumulated sludge. Unless these devices are perfectly arranged so that the chemical action and clearing of the water are carried on systematically, the results are far from satisfactory. Some of the water drawn from the storage tank may enter the boiler without being properly softened and the good of the whole practice be thus greatly lessened.

Probably the most satisfactory and efficient method of softening and purifying very hard waters, and those which carry corrosive acids and other injurious ingredients is one by which machinery is operated by the flow of water to agitate the water and mix the chemicals continuously. Simple, but effective mechanical devices are used to regulate the flow of the chemicals, and in addition the water is preheated in order to hasten chemical action. In this way the proper amount of chemicals for each thousand gallons of water is mixed with hot water before the flow enters the sedimentation tank.

When this tank is finally entered, chemical action is already well under way. To prevent any part of the water from being acted upon unduly, mechanical agitators stir it continually. The water is thus rapidly and perfectly softened, and then it passes through a filter preparatory to entering the boiler. It is as nearly perfect as possible after passing through these different stages of purification, and the whole mechanical part of the process is operated by the action of the flow of water itself. There are many devices, more or less elaborate and intricate, for regulating the whole process of softening the water, but in large plants the automatic methods are always the best, for there is less danger of neglect of some part of the supply.

In general it may be said that water softening saves loss of service of boilers to such an extent that added profits are easily apparent, and that in the end the checking of rapid deterioration of boilers is important. Saving in repair bills is also an item that may be found in most plants a great consideration. The increased service obtained continuously and without interruption from steam generators makes water-softening plants of special interest to engineers, who are looking for the maximum output of their plants at the minimum expense of operation. Both to the boiler maker and the operating engineer is the preservation and highest efficiency of the boiler through any mechanical or chemical means a point of great importance.

How to Lay Out a Tubular Boiler.

PART III.

BY H. S. JEFFERY.

In the preceding articles the efficiencies of both lap and butt-joint seams have been found for different sizes of rivets. With the treble-riveted butt joint with inside and outside straps, ¾-inch rivets, a factor of safety of 4.2, tensile strength of the plate 60,000 pounds per square inch, and thickness of plate 7/16 inch, the boiler under consideration was found good for 181 pounds per square inch steam pressure. The strength of a section of plate, the length of one pitch of rivets, is equal to $60,000 \times 5.4875 \times 1.4375 = 144,047$ pounds. The stress on a similar section of the boiler shell, due to a steam pressure of 181 pounds, is equal to $\frac{60 \times 6.3 \times 181}{2} = 34,209$ pounds.

Thus we have a stress of 34,209 pounds upon a section capable of withstanding a stress of 144,047 pounds. Dividing the latter

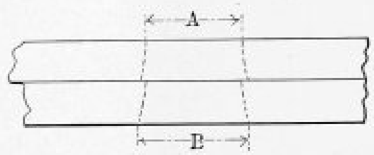


FIG. 9.—EFFECT OF PUNCHING HOLES IN LIGHT PLATE.

by the former gives, of course, the factor of safety, $144,047 \div 34,209 = 4.2$ factor of safety. This, as will be seen, checks the other calculations.

Thickness of Butt Straps.

To ascertain the thickness of butt straps, the area of a section of the strap at its weakest point for one pitch may be made equal to the area of the section of the plate at its weakest point for one pitch. The weakest point in the butt straps is along the line of holes nearest to where the plates butt, since

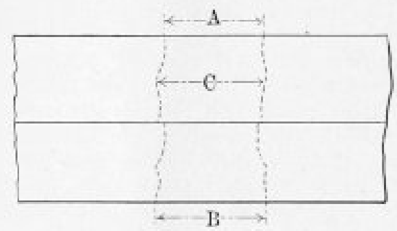


FIG. 10.—EFFECT OF PUNCHING HOLES IN HEAVY PLATE.

this section receives no assistance from the shearing strength of the rivets. The weakest point in the plate is at the outer row of rivets.

If A = net section of plate at outer row.
B = thickness of plate.
C = net section of plate at inner row.
D = thickness of straps.

Then $D = \frac{A \times B}{C}$

$$\frac{5.4875 \times .4375}{2.3375 \times 2} = .514 \text{ inch, thickness of both straps.}$$

$.514 \div 2 = .257$ inch, thickness of one strap.

This is a fraction over ¼ inch thickness. As it is the minimum thickness, it would be better to make the straps at least ⅜ inch thick. Frequently the thickness of the strap is made ⅝ the thickness of the plate.

Welded Joints.

It has been generally proved in actual tests that welded joints are unreliable, due to the uncertainty of the weld. Even where perfect welds have been made, the strength of the joints has not proved equal to the strength of the plate. Since the main idea in boiler construction should be to make all parts of as nearly equal strength as possible, it would not be good practice to use a joint whose strength is uncertain.

In the preceding articles we have found by means of different formulæ and different methods of doing work, the pressure which would be allowed on the boiler under different conditions. Actual conditions will upset these calculations to a certain extent, as it will be found impossible in general work thickness of every plate is greater at the center than at the edge, and the wider and thinner the plate the greater is this variation. This variation will certainly have its effect when the sheet is rolled up; also the punching may cause the hole to vary slightly, so that when the sheet is connected some of the holes may be slightly unfair.

In Fig. 9 is shown the section of a rivet hole punched full size in a light plate. In light plates, with good punches and dies, the holes will be slightly tapered. In heavy plates the metal is so compressed that it will tear the sheet in the center of the thickness of the plate, causing the diameter of the holes to vary according to the thickness of the plate. A section of holes punched full size in heavy plates is shown in Fig. 10. *C* is ⅛ inch greater in diameter than *A*, and is also larger than *B*. It will readily be seen how difficult it is to upset rivets so as to fill the entire hole. Rivets driven in holes of this shape will leak, since the holes are not properly filled. It is almost impossible to remove or knock out one of these rivets after its

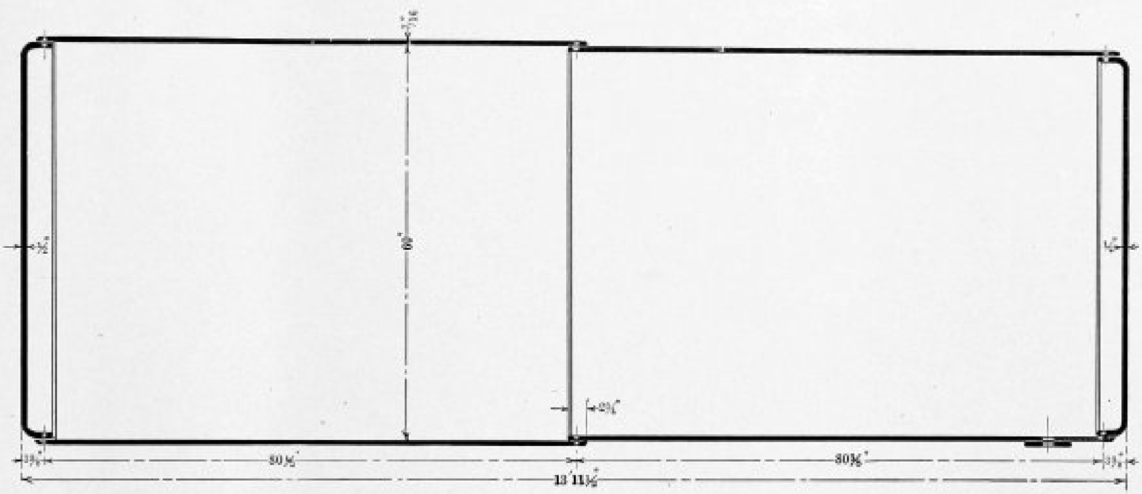


FIG. 11.—SECTION SHOWING OUTLINE OF BOILER SHELL AND HEADS.

to calculate the distances such that the rivet holes can be stepped off exactly to the pitch as found by the formulæ. It may be a fraction one way or the other, and this will effect the percentage of strength to a slight extent; thus it will be seen that both a scientific and practical education are of great importance for the layer out, in order that he may know what the effect on the efficiency of the joint will be when he finds it necessary to increase or decrease the pitch of rivet holes to cover a certain distance. It is quite impossible to make laws or rules defining the exact pitch for the strength of all the joints, for the reason that the pitch in nine cases out of ten cannot be stepped off in equal spaces. Only the maximum pitch allowable for a certain size of plate can be fixed exactly.

Preceding examples have shown the effect on the percentages produced by punching holes full size, by punching small and reaming out, and also by drilling in place. Another feature must be taken into consideration, and that is the damage done by punching. On light plates the damage is not great, but it increases as the plates increase in thickness. It is estimated that holes punched full size damage the strength of plates from about 8 percent in ¼-inch steel plates to 33 percent in ¾-inch plates. In plates having the holes punched small and reamed out, this damage is obviated to a large extent. Actual experiments show that the punched holes make the plate between the rivet holes less in tensile resistance according to the thickness of the plates from 6 to 20 percent.

It is utterly impossible for each and every hole to be fair regardless of the care exercised in laying out. This is due partly to the great variation in the thickness of plates. The head has been cut off. The effect of all such conditions upon the factor of safety has been clearly shown by the preceding examples.

Size of Shell Plates.

Since the boiler under consideration is 60 inches in diameter and 14 feet long, the shell can be made in two equal courses. The circumference to be used for the length of the plates may be found by multiplying the inside diameter of the boiler by 3.1416, and adding to the result three times the thickness of the plate, by multiplying the outside diameter of the boiler by 3.1416 and subtracting three times the thickness of the plate, or by multiplying the mean diameter of the boiler measured to the center of the thickness of the plate by 3.1416. The latter method is the correct one to use. Since the inside diameter is 60 inches, and the thickness of plate 7/16 inch, the mean diameter will be 60 7/16 inches. The circumference corresponding to this diameter is 189.87 inches. If the circumference corresponding to the inside diameter had been found and three times the thickness of the plate added, the result would have been 189.81 inches. If the circumference corresponding to the outside diameter had been found and three times the thickness of the plate subtracted, the result would have been 189.93 inches.

The circumference, 189.87 inches, will be the length of the plate for a butt joint. For a treble-riveted lap joint the distance between the rivet holes and the laps must be added. Assuming a distance between rivet holes of 1⅝ inches and a lap of 1⅜ inches, the length of the plate would be

$$189.87 + 2 \times 1\tfrac{5}{8} + 2 \times 1\tfrac{3}{8} = 189.87 + 6 = 195.87 \text{ inches.}$$

This would be the length for the large course. Make the small course six times the thickness of the plate shorter. It is a good idea to allow 3/8 inch more for squaring up the sheet, making the total length about 196¼ inches.

In determining the length of the boiler we will figure on using 14-foot flues. It will be necessary to make allowance for the beading of the flues, which would require, roughly, ¼ inch at each end, making ½ inch in the total length; therefore, the length of the boiler from outside to outside of the heads will be 13 feet 11½ inches.

We will assume that the heads are to be flanged to a 2-inch outside radius. It has been previously decided to make the laps 1 3/8 inches; therefore, to prevent the calking edge of the plate extending onto the curved part of the flange, the gage line for the rivets on the head should be 2 + 1 3/8 = 3 3/8 inches from the outside of the head. Therefore, for both heads, the total distance will be 2 × 3 3/8 = 6¾ inches. Subtracting 6¾ inches from 13 feet 11½ inches for the distance between the rivet lines in the heads leaves 13 feet 4¾ inches, or 160¾ inches. Dividing 160¾ by 2 we get 80 3/8 inches as the width of each shell plate from center to center of the circumferential seams. For the total width of these plates add the laps.

$$1\tfrac{3}{8} \times 2 = 2\tfrac{3}{4} \text{ inches.}$$
$$80\tfrac{3}{8} + 2\tfrac{3}{4} = 83\tfrac{1}{8}.$$

Add an allowance, say 3/8 inch, making the total width of the plate 83½ inches. Some do not make such a great allowance.

Size of Heads.

Some authorities have certain stated thicknesses of heads for certain diameters of boilers. The heads should be at least as heavy as the shell, and in most cases slightly heavier. Let us

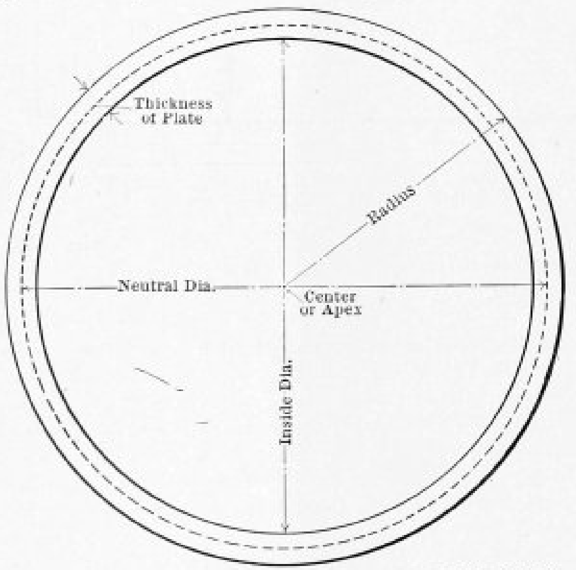


FIG. 12.—SECTION SHOWING DIMENSIONS OF SHELL PLATE.

make the heads ½ inch thick in the boiler under consideration. The pressure this plate will stand will be figured out when laying out the braces and flue pitches. The majority of shops order boiler heads equal in diameter to the length of a cross-section of the flanged head measured at the center of the thickness of the plate. This is not bad practice, but it allows a fraction more than is necessary.

If A = outside diameter of the head.
B = outside radius of the flange.
C = ¼ circumference of the flange at the center of the thickness of the plate.
D = ½ of $A - B$.
$E = F - B$.
F = depth of flange.
16 = constant.

Then, as seen from Fig. 13, the length of a cross-section of the flanged head measured at the center of the thickness of the plate will be $2D + 2C + 2E$.

$$56 + 2 \times 2.75 + 2 \times 2.75 = 67 \text{ inches.}$$

This, according to the above rule, would be the diameter of the head before flanging. The writer has originated the following rule for determining the amount which would be gained in this length in the operation of flanging:

$$\frac{\frac{E + C}{2} \times 16}{F \times \frac{1}{2}A} = \text{gain in flanging.}$$

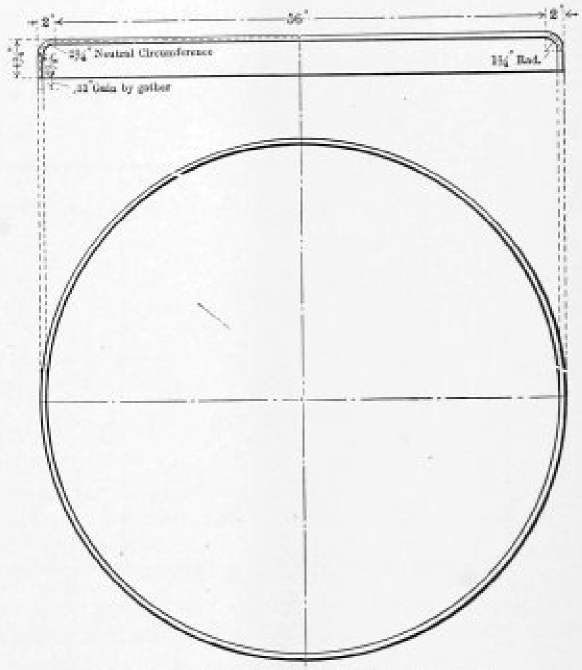


FIG. 13.—PLAN AND ELEVATION OF HEAD.

$$\frac{\frac{2.75 + 2.75}{2} \times 16}{4.75 \times 30} = \frac{88}{285} = .31$$

Therefore, .31 equals the amount to be taken off all around, due to the gain caused by the gather of the material when flanged. Thus 67 — .31 = 66 5/8 inches diameter. This is for the large head. Since the small head is 7/8 inch less in diameter a similar calculation should be made for it.

Association Notes.

Col. M. F. Cole, president of the American Boiler Manufacturers' Association, promises a big surprise in the way of entertainment for the members of the association who attend the nineteenth annual convention, which is to be held at Atlanta, Ga., next October.

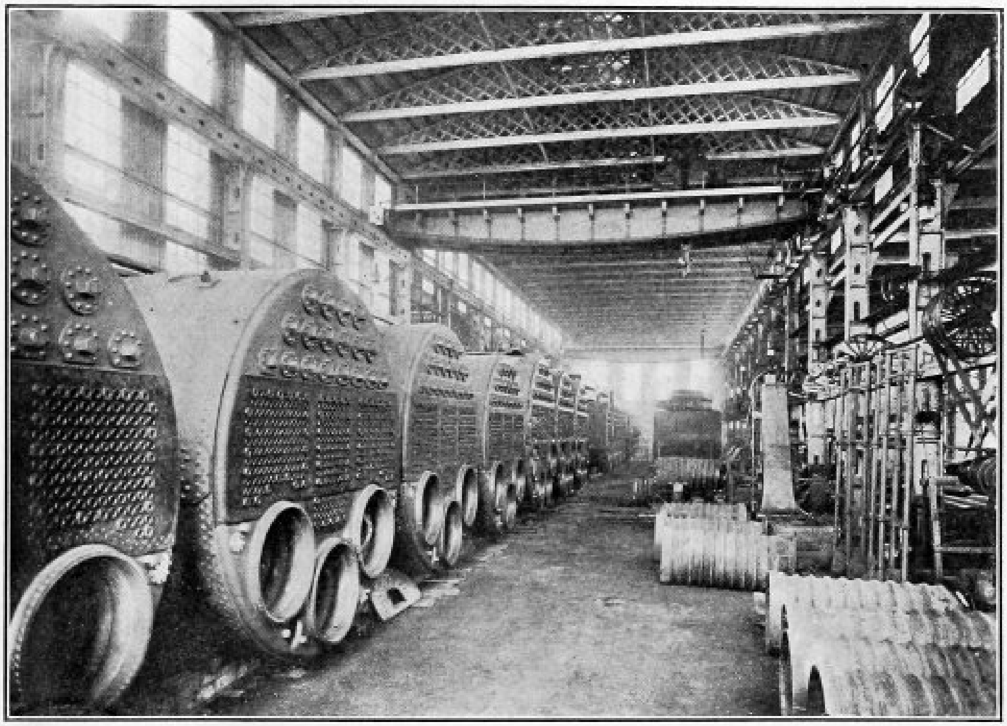
The Hollenden Hotel at Cleveland, Ohio, has been secured for the joint convention of the Master Steam Boiler Makers' Association and the International Railway Master Boiler Makers' Association which meets on May 21, 22 and 23.

Remember that the Champion prizes of $50, $35 and $25 for the best articles on "How to Heat and Drive Steel Rivets" are to be awarded at the joint convention of Master Boiler Makers at Cleveland, in May.

The Boiler Shop of the Harland & Wolff Shipbuilding Plant.

Before the middle of the nineteenth century a small shipyard was in operation on Queen's Island, Belfast, Ireland. This yard has been in continual operation since that time, and has now grown until it is the largest shipbuilding plant in Ireland and in some respects the largest in the world. In 1861 the manager of this yard, who was later Sir Edward Harland, entered into partnership with Gustavus Wolff, forming the present firm. Lord Pirrie, the present head of the firm, was made a partner in 1874.

Since the works are entirely self-contained the propelling machinery for the many large ships which have been constructed here has been built in the yard. This has given rise to a large amount of boiler construction, especially of the Scotch marine type. The boiler shop is not only large, but it is equipped with all types of modern machinery and appliances for handling work. The view of the shop, which is shown herewith, gives some idea of the construction and size of the building as well as the crane service and amount of work which can be in progress at any one time.



VIEW IN THE HARLAND & WOLFF BOILER SHOP, SHOWING A ROW OF COMPLETED BOILERS.

During the year 1906 this firm built and engined ships with a total of about 68,000 indicated horsepower, a fact which gives some idea of the amount of boiler construction necessarily carried on to provide this power. When water-tube boilers first came into use in the British Navy it was found impossible to attain the extreme economy given by the Scotch boilers. Harland & Wolff are said to have been responsible for the fitting in several of the British naval vessels of a combination of Scotch and water-tube boilers. The Scotch boilers were designed to furnish about one-fifth of the total steam required for full power, and were used in cruising. They could then be worked at nearly full capacity, and so gave splendid efficiency. Since, however, the efficiency of water-tube boilers has been increased, this practice has been discontinued.

Boilers for Railway Motor Cars.

The problem of utilizing motor cars for suburban railway service has been receiving considerable attention of late by railway companies, especially in England; and has led, chiefly for commercial reasons, to the adoption of the self-contained steam propelled car. The condition of service which has brought this type of car into existence is the increasing demand for more frequent and more rapid suburban service than railroads can supply with ordinary trains. There are two different methods of service which might be established to meet this need: one, electrical, and the other steam. The Taff Vale Railway, England, has made a complete study of the relative cost of these two methods with a view to establishing the more economical one on their lines. If electricity is used there are four different ways in which it may be applied; self-contained cars operated by storage batteries or by dynamos driven by gasoline engines, the third-rail system, the overhead system with a bonded or new return rail, and lead and return rail system.

The chief reason why the last three methods did not prove feasible is because the load factor is poor. The intermittent service and heavy grades tend to make the "peak" load large, and to make great fluctuations in the load factor. Also for a long line if the distance from the power house is great, the power installation must be unnecessarily large in proportion to the work done. All this tends to make the first cost of an installation of any of three latter kinds impracticable. Self-contained cars operated either by storage battery or a dynamo driven by a gasoline engine, present a very heavy initial cost and are also expensive in maintenance. With a car driven by batteries there are also comparatively long periods of inactivity while the batteries are being charged.

Gasoline electric cars with auxiliary storage batteries have been tried in this country, and have proved successful. In these cars the current generated by the dynamos can be switched from the motors to the batteries when the car is not in motion. The batteries are then used to assist the dynamos over the peaks of the load.

The self-contained steam motor car has thus far proved more economical, and has come into more or less extensive use on English railroads. The success of such a car depends largely, of course, upon the efficiency of the boiler, which must occupy only a small space and be capable of raising steam quickly and economically. Therefore, the boiler should have a large ratio of heating surface to grate area. At the same time the boiler must be of a type likely to occasion a minimum amount of repairs and give easy access for washing, etc. As a result of this many types of boilers have been tried, and illustrations of some of the more successful of these are shown herewith.

One of the first railroads to use this service successfully was the Taff Vale Railway, England. The boiler used on their cars is shown in Fig. 4. It is of the locomotive type with two barrels, the fire-box and combustion chamber being in the middle. Each barrel has 232 tubes, 1⅝ inches in diameter, which lead to a smoke-box at either end. The top of the combustion chamber is supported by girder stays, and the part of the flue sheets above the tubes is stayed by through stays running the entire length of the boiler. The steam space is increased by a dome directly over the combustion chamber. The total heating surface of this boiler is 464.84 square feet, and the grate area is 10 square feet, making a ratio of 46.5. Due to its large heating surface in comparison with the small space occupied the boiler has fulfilled that most essential requirement of this service, viz.: that of raising steam quickly. The boiler carries 180 pounds steam pressure.

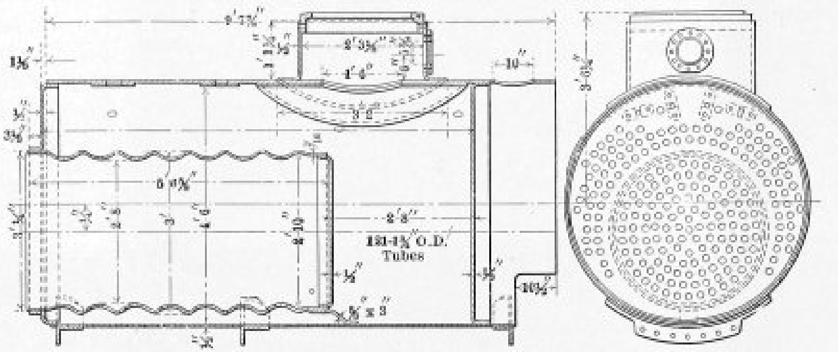


FIG. 1.—SIDE AND END ELEVATION OF BOILER USED ON CANADIAN PACIFIC RAILROAD.

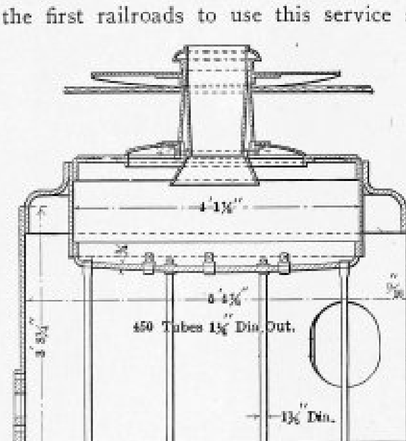


FIG. 2.—VERTICAL BOILER USED ON GREAT CENTRAL CARS.

In Fig. 2 is shown the type of boiler used on the Great Central Railroad, England. This is an ordinary vertical submerged fire-tube boiler 5 feet 4⅞ inches in diameter. The boiler has a copper fire-box and 450 tubes 1¼ inches outside diameter. The thickness of shell is 9/16, and the boiler carries 150 pounds pressure. The total heating surface is 610.36 square feet and grate area 13 square feet, making a ratio of heating surface to grate area of 47.

The Canadian Pacific Railroad has used a horizontal return tubular boiler. This is shown in Fig. 1, and it will be seen that it is a modified type of Scotch boiler, having a circular furnace, an intermediate or combustion chamber and a superheater. It is 4½ feet inside diameter by 7 feet 11 inches length between flue sheets. It contains one 33-inch corrugated furnace and ninety-five 1¾-inch tubes. There are 485 square feet of heating surface in the tubes and 61 square feet in the furnace, making a total of 536 square feet. The superheater consists of thirty-one 1¼-inch steel tubes and contains 62 square feet of heating surface. The shell and heads of the boiler are of ½-inch plate. The fuel used is crude oil, which is carried in a tank having a capacity of 2,000 pounds under a constant air pressure of 15 pounds per square inch. The oil is fed to the furnace by a slot burner, and the supply cock and blower are controlled by an automatic device. The car is provided with water tanks having a total capacity of 900 imperial gallons. The tanks are fastened to the under side of the car body, and the water is fed to the boiler by one No. 3 and one No. 5 injector. The working steam pressure is 180 pounds per square inch, and the steam is superheated, so that upon reaching the valve chest it has a temperature of from 700 to 760 degrees F. The corrugated flue in the boiler is lined with fire-brick, and the boiler is also equipped with a sand-blowing device for cleaning soot off the tubes.

The small locomotive boiler has been used by several different lines. Fig. 3 shows a boiler of this type in use on the Lancashire & Yorkshire Railroad. It is 4 feet 3 inches in diameter, and contains 199 tubes 1¾ inches in diameter. The length between flue sheets is only 5 feet. There are 455 square feet of heating surface in the tubes and 54 square feet in the fire-box, making a total of 509 square feet. The grate area is 9.4 square feet, making a ratio of heating surface to grate area of 54.2. The working steam pressure is 180 pounds per square inch, and provision is made for carrying 550 gallons of water and 1 ton of coal on the car.

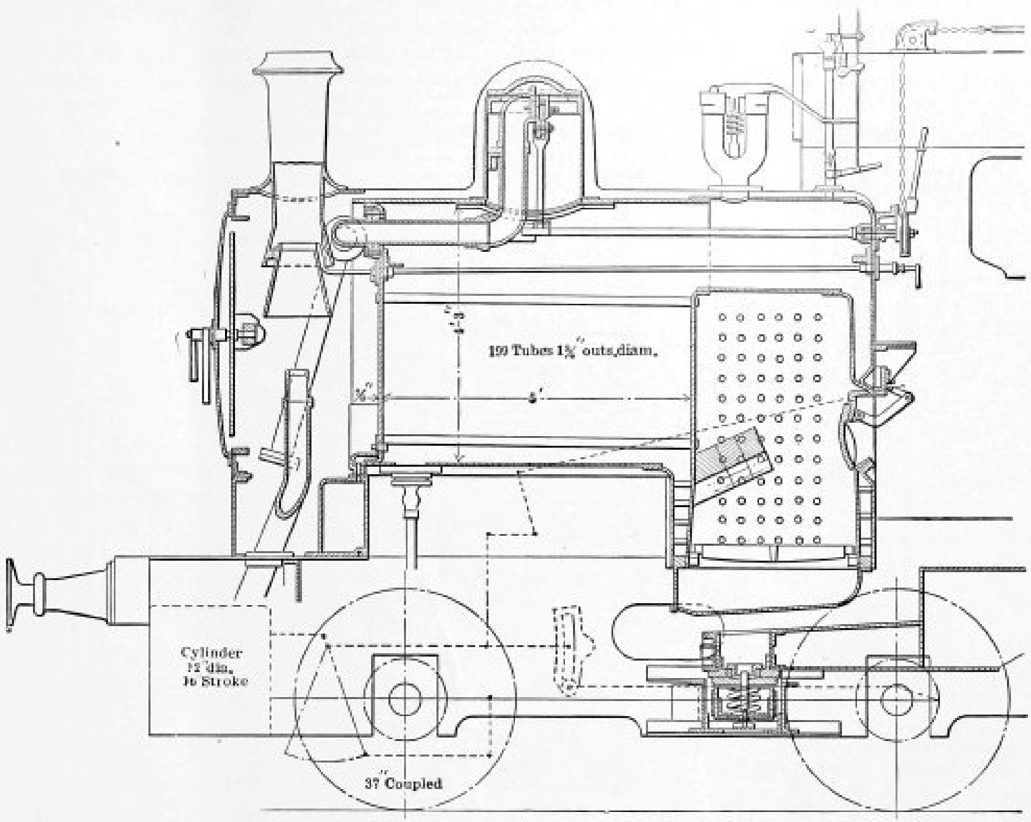


FIG. 3.—LOCOMOTIVE TYPE OF BOILER USED ON LANCASHIRE AND YORKSHIRE CARS.

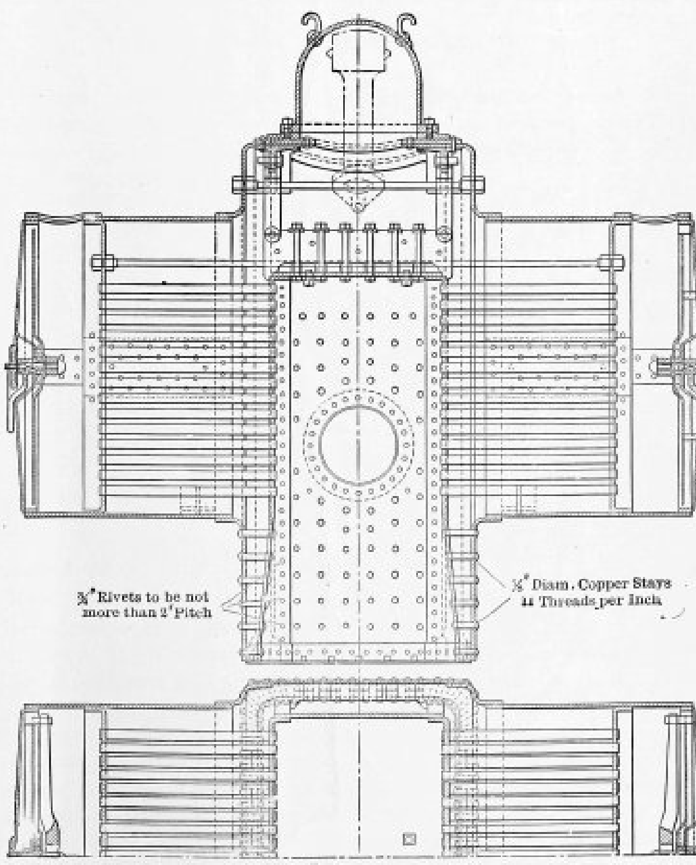


FIG. 4.—TYPE OF BOILER USED ON THE TAFF VALE RAILWAY CARS.

A boiler of an essentially different type is shown in Fig. 5. In this boiler the furnace is beneath the center of the boiler and the gases are led first into a combustion chamber and then through a set of horizontal tubes to a second combustion vertical boiler, and has been used in a motive car on the Central South African Railway.

In the table on the opposite page are tabulated for comparison the principal details of a number of these boilers.

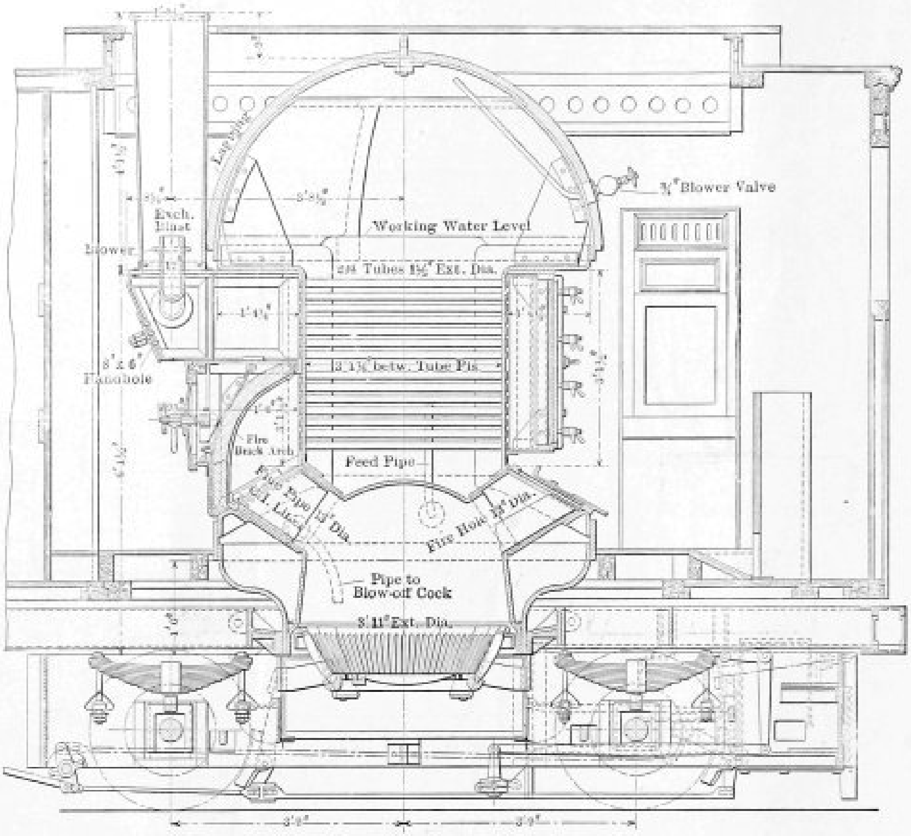


FIG. 5.—THE COCHRAN VERTICAL MOTOR CAR BOILER.

chamber on the opposite side of the boiler, and finally through a second set of horizontal tubes above the first set into the smoke-box. The top of the boiler is in the shape of a dome

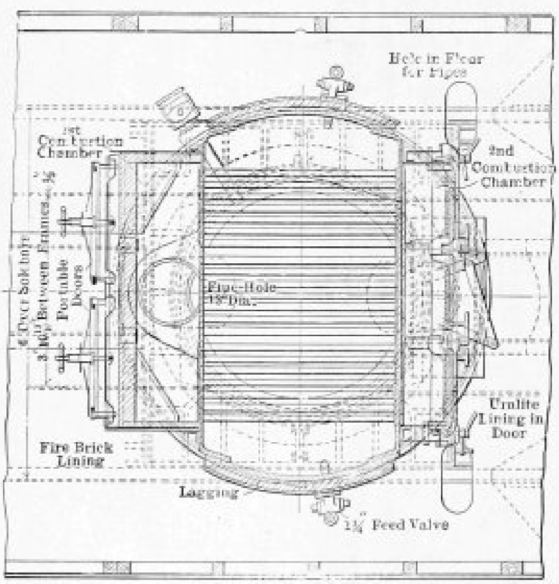


FIG. 6.—PLAN VIEW OF COCHRAN BOILER.

giving an exceptionally large steam space. There are 294 tubes 1½ inches outside diameter. The distance between flue sheets is 3 feet 1⅞ inches. This is known as the Cochran

It was found from experiments on the Canadian Pacific motor car that with a 200-horsepower engine the results obtained in locomotive practice on large boilers and on large engines can be duplicated in every respect. The inches of draft per pound of back pressure can be duplicated. The evaporation per square foot of heating surface is duplicated. The horsepower the car will develop is practically the same and the weight of the boiler per square foot of heating surface is rather less than in an ordinary locomotive; therefore, experience has shown that it is safe to apply existing locomotive data to very small cars of that kind and expect the results to be duplicated. One objection which has been found in this type of car is the difficulty of washing out the boiler. A small boiler, such as used, must be washed out properly just as a large one, but the washing is a much more difficult and unsatisfactory task in a small boiler than in a large one.

A Y-Breeching.

BY JOHN COOK.

Figs. 1 and 2 represent a style of breeching that has been in use for over thirty years. I believe it was first designed by the Erie City Iron Works, of Erie, Pa. It is very simple in construction and easy to make, and in my judgment, when properly proportioned, makes a very neat job. In some shops where a great variety of sheet iron work is done, there is generally a large number of pieces lying around the shop large enough to make one of these breechings or the greater part of it. By making it in small sections as shown, it is easily worked up and put together.

To lay out such a breeching, first strike up one-half of the

TABLE SHOWING A COMPARISON OF THE DETAILS OF BOILERS USED IN RAILWAY MOTOR CARS.

RAILWAY.	Heating Surface.	Grate Area.	Ratio.	Details.
Taff Vale	464.84	10	46.5	Locomotive type—two barrels, 232 1⅝ in. tubes and smoke box each; 180 pounds pressure.
Great Central	610.36	13	47	Vertical—5 ft. 4⅝ in. diameter, 150 pounds pressure; copper firebox, 450 tubes, 1¼ in. diameter.
Canadian Pacific	600	oil burner	....	Return tube—4½ ft. diameter, 160 pounds pressure; 33-in. circular furnace, 95 tubes, 1¾ in. diameter; superheater with 31 tubes, 1½ in. diameter.
Lancashire & Yorkshire	509	9.4	54.2	Locomotive type—4 ft. 3 in. diameter; 199 1¾-in. tubes; 180 pounds pressure.
Central South African	......	......	....	Cochran Vertical—294 1½-in. tubes in two sets, with two combustion chambers.
Great Western	659.24	11.54	57.1	Vertical—4 ft. 6 in. diameter, cone top; 160 pounds pressure; 458 1⅝-in. tubes.
Great Northern (Scotland)	500	9	55.6	Vertical—150 pounds pressure.
Great Northern (Ireland)	653.1	11.5	56.7	Vertical—420 1½-in. tubes; 175 pounds pressure.
Missouri Pacific	......	......	....	Water tube—250 pounds pressure.
Port Talbot	660	13.1	50.4	Locomotive type—170 pounds pressure.
London & North Western	317.27	6.38	49.7	Locomotive type—175 pounds pressure.
Great Southern & Western (Ireland)	367.66	8.4	43.7	Locomotive type—309 1¾-in. tubes; 130 pounds pressure.
Glasgow & South Western	......	......	....	Locomotive type—142 1⅝-in. tubes.
Great Northern	382	9.5	40.3	Locomotive type—175 pounds pressure.
London & South Western	347	6.75	51.4	Locomotive type—firebox fitted with water tubes.
North Staffordshire	368	7	52.6	Locomotive type—180 pounds pressure.
London, Brighton & South Coast	369	7	52.7	Locomotive type—242 1¾-in. tubes.

side elevation, Fig. 3, the desired size as follows: First lay down the center line *JR*. Then lay out the band or upper part. Then the branch piece; also sketch up the slope of the connection at the bottom, as shown, and erect vertical lines from where the circular part begins. This represents the round part of the leg. Now, strike square lines across all of the different pieces in Fig. 3, and on the round part strike the

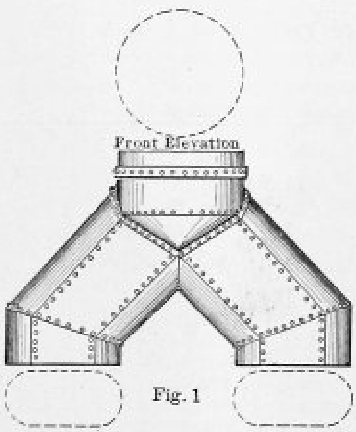


Fig. 1

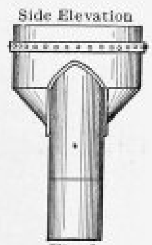


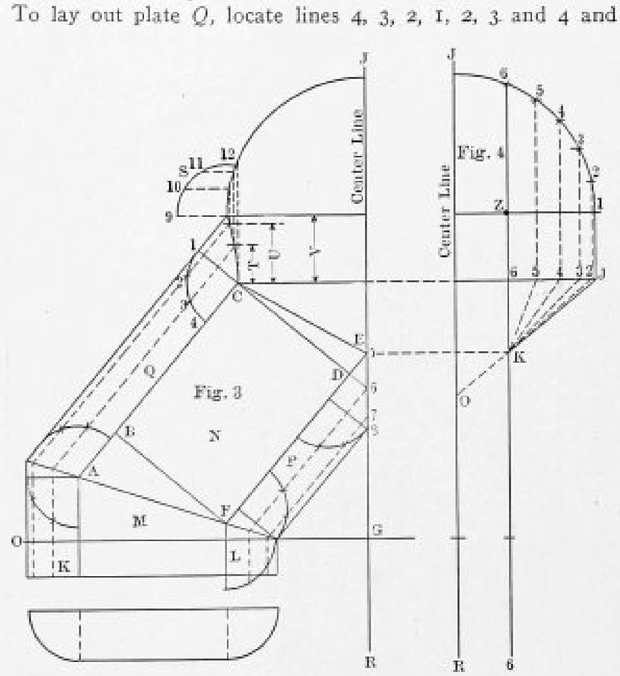
Fig. 2

quarter circles and divide them into any number of equal parts as shown, in this case three parts, and number them 1, 2, 3 and 4. Then extend lines through these points at both ends as shown. Now strike the quarter circle on top, which represents the diameter of the part where the stack is to fit, and on the side strike another quarter circle, as shown at *S* in Fig. 3, equal in diameter to the round part of the leg, and divide it into the same number of parts as at 9, 10, 11 and 12. Extend these lines to cut the large circle as shown. Now drop the dotted lines as shown to cut the lines on the leg, and a line traced through these points will be the miter line, or, in other words, will be the points where the leg will strike the main diameter. We are now ready to lay out the plates which make up the leg. You will note that each part, as lettered *K*, *L*, *M*, *N*, *P* and *Q* in Fig. 3, has a similar letter on the plates which are laid out.

TO LAY OUT THE LEG PLATES.

Take *K*, Fig. 3, and lay it out as shown in plate *K*. First find the circumference and space it off in twice as many parts as the quarter circle in Fig. 3 is divided into, and as shown in plates *K* and *Q*, and number them as 4, 3, 2, 1, 2, 3 and 4. Then take the distance from the line *OG*, Fig. 3, to where line 1 strikes the miter line, and mark off a corresponding distance from line *OG*, plate *K*, on the center line. Now take the length of line 2 from *OG*, Fig. 3, and mark off a corresponding distance on line 2 each side of the center line on plate *K*. Then get the length of lines 3 and 4 from Fig. 3 and transfer them to plate *K*. Then by tracing lines through these points you will have the miter line on plate *K*, and by laying out rivet holes on the miter line, also on the seam, and add for laps, plate *K* will be complete.

To lay out plate *Q*, locate lines 4, 3, 2, 1, 2, 3 and 4 and



make them any length longer than the plate. Now the shop way of laying this out is to take a strip of iron, lay down on Fig. 3, and mark the square line on either end, and then mark the distance from the square line to the miter line on both ends as found by the quarter circles on lines 1, 2, 3 and 4, and transfer these lengths to plate *Q* on lines 4, 3, 2, 1, 2, 3 and 4, and lines drawn through these points will be the miter line or line of rivet holes. Now, by laying out the necessary rivet holes around the edges and adding for lap, plate *Q* will be complete. Plates *P* and *L* are laid out in the same manner.

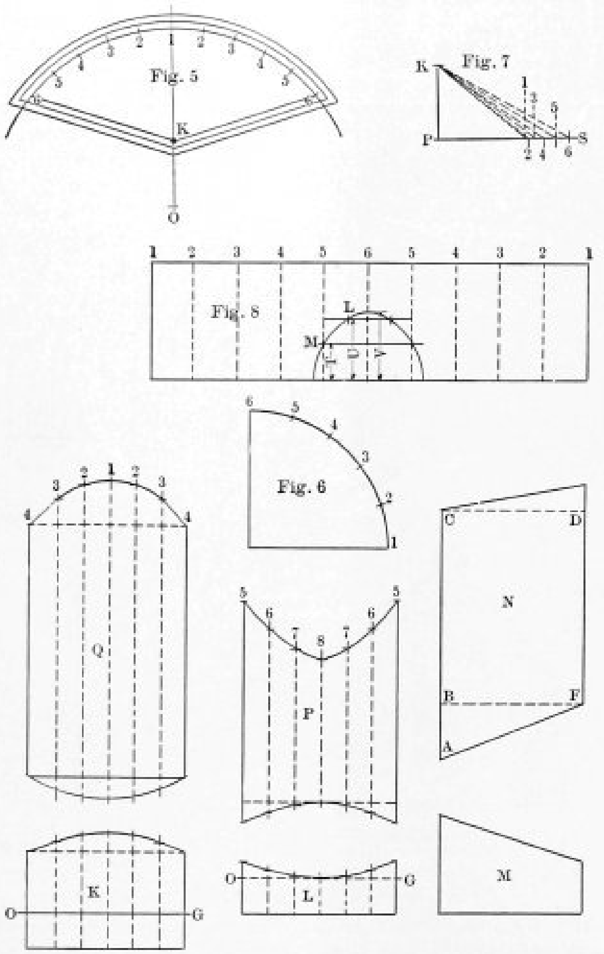
TO LAY OUT THE FLAT PART OF SIDES.

All that is necessary to develop the side pieces is to first start on plate *M* and lay down the bottom line, then erect the perpendicular lines, taking the miter line as the height, and draw the miter line as shown in plate *M*. Then locate your rivet holes on the seams and the miter line and add for lap and plate *M* will be complete.

Plate *N* is laid out in a similar manner, or, in other words, transfer the lines on Fig. 3, plate *N*, to the sheet which you wish to use for this purpose, locate your rivet holes, add for lap, and the development of the sheets for the leg will be complete.

TO LAY OUT TOP, OR FIG. 8.

For this purpose Fig. 6 may be used. Fig 6 is a quarter circle of the top ring divided into five spaces. Fig. 8 represents one-half of the top spaced from Fig. 6 from 1, 2, 3, 4, 5, 6, 5, 4, 3, 2 and 1. The object of Fig. 8 is to show how to lay out the hole where the round part of the leg, Fig. 3, strikes the top. First take the distances marked *T*, *U* and *V*, Fig. 3, and transfer them to Fig. 8 as shown. Now, take the lengths of lines 9, 10, 11 and 12 on Fig. 3 from the quarter circle *S* and transfer them to Fig. 8, each side of the center line 6,



as shown at *L*, *M* and the bottom line; then a line traced through these points will be the cut out of the hole.

TO LAY OUT THE BREAST PLATE.

First sketch up Fig. 4. Line *JR* is the center line. Then strike the quarter circle and divide that portion where the breast plate strikes into any number of equal parts, in this case five, and number them as 1, 2, 3, 4, 5 and 6, and square these lines down to the base of the main ring as denoted by 6, 5, 4, 3, 2 and *J*. Now extend these dotted lines to point *K* and you are ready to lay out the breast plate, Fig. 5. One way to develop this plate is on the same principle as a cone is laid out. Another is by triangulation. To lay this out by the first method is to extend line *JK*, Fig 4. to the center line *O*, and with radius *OJ* strike the curve line on Fig. 5, using *O* as a center, and with dividers set around the circle, Fig. 4, mark off points 1, 2, 3, 4, 5 and 6, Fig. 5. Now get the length of line *JK*, Fig. 4, and from point 1 of Fig. 5 mark point *K*. Now draw lines from points 6-6 to *K*, and you have the flange line. Now add for the necessary flanges and lay out your rivet holes and the sheet will be complete.

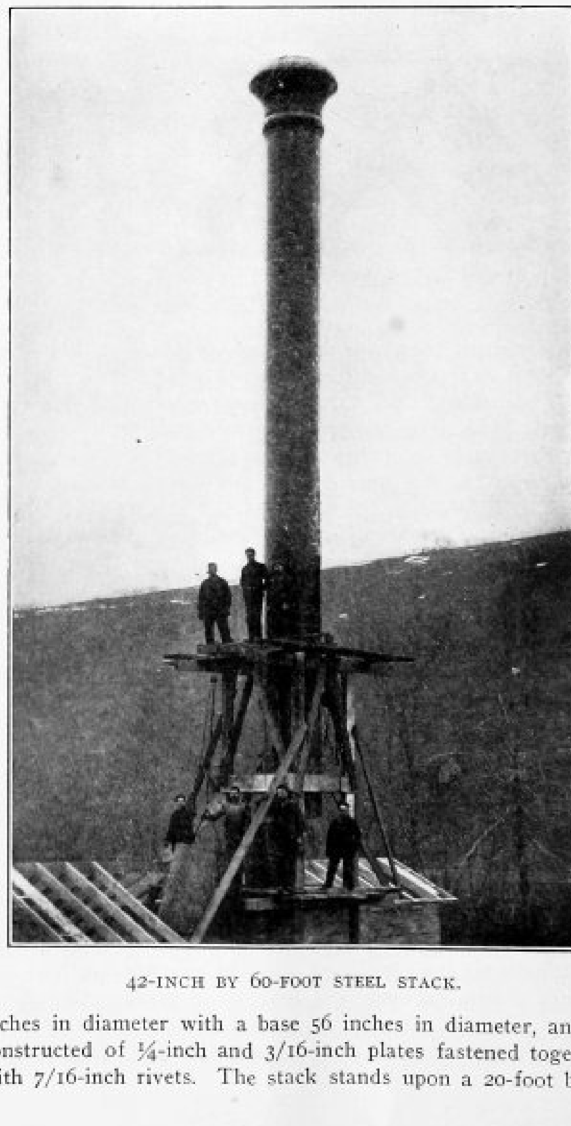
TO LAY OUT THE BREAST PLATE BY TRIANGULATION.

Strike up Fig. 7 in the following manner: First lay down line *PS* and strike the perpendicular line *PK* at right angles. Next take the perpendicular height, Fig. 4, from 6 to *K*, and mark off from *P* to *K*, Fig. 7. Now with *Z*, Fig. 4, as a center, take the distances from *Z* to 1, *Z* to 2, *Z* to 3, *Z* to 4, *Z* to 5 and *Z* to 6, and mark off a corresponding distance on line *PS*, Fig. 7, as shown, numbered 1, 2, 3, 4, 5 and 6; then extend lines from these points to point *K*, as shown by dotted lines. Then you are ready to develop Fig. 5 by triangulation.

Take the distance from *K* to 1, Fig. 7, and mark off a corresponding distance from *K* to 1, Fig. 5. Now with your dividers set to spaces on the circle, Fig. 4; mark one space, Fig. 5, each side of 1 as 2, 2. Then with tram points set from *K* to 2, Fig. 7, mark off a corresponding distance from *K* to 2, Fig. 5. Then from points 2 mark off another space at 3 each side, and with tram points set from *K* to 3, Fig. 7, mark off the same distance from *K* to 3, Fig. 5; then take the length of the rest of the lines in Fig. 7 from *K* to 4, *K* to 5 and *K* to 6, and transfer to Fig. 5, each time marking one space with the dividers as shown, and you will get the same results as you did by the first method. Then add for your rivet holes and flanges and the sheet will be complete.—*Motive Power.*

The Rapid Erection of a Stack.

The accompanying illustration shows a 60-foot steel self-supporting stack in the process of erection. This stack is 42



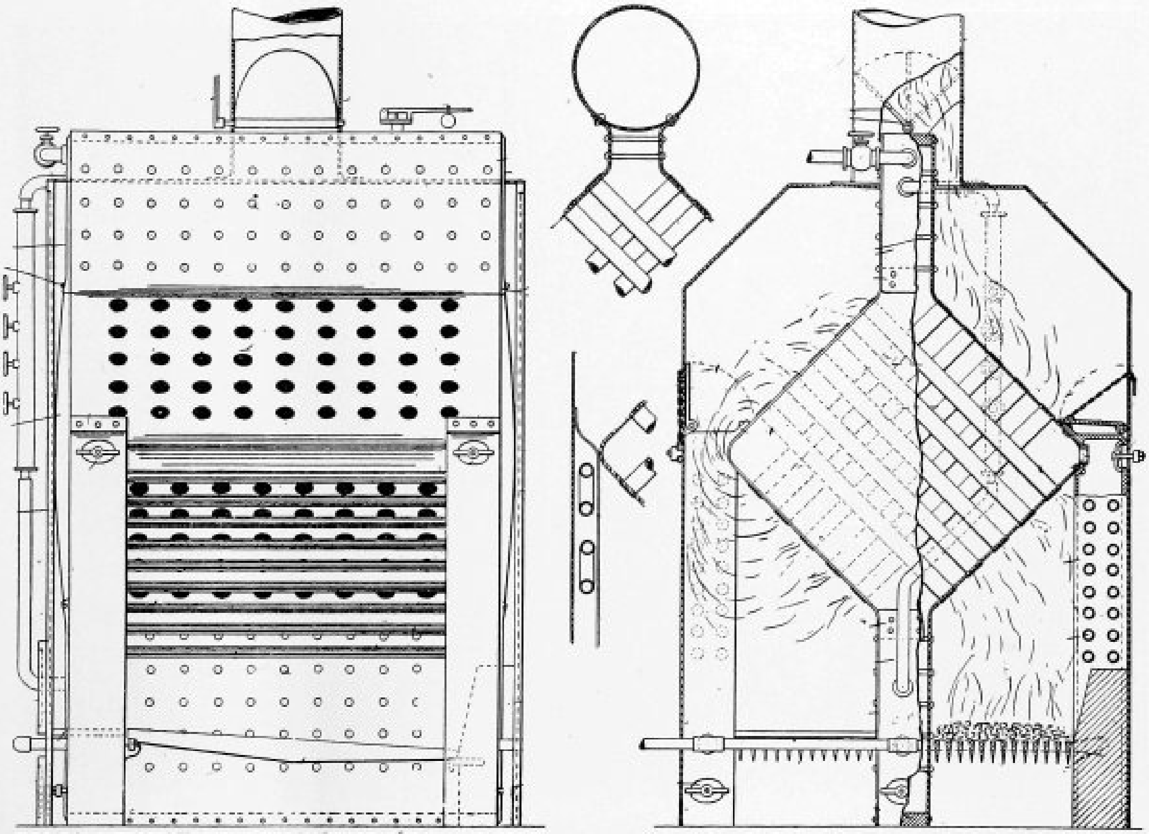
42-INCH BY 60-FOOT STEEL STACK.

inches in diameter with a base 56 inches in diameter, and is constructed of ¼-inch and 3/16-inch plates fastened together with 7/16-inch rivets. The stack stands upon a 20-foot base.

Although this is a comparatively small stack, yet it was erected in record time. After the sections in which the side seams were already riveted were delivered on the ground and the scaffold erected, it took just 6 hours and 30 minutes to complete the stack, raising it a section at a time. This is a common method used by this particular crew, consisting of six men, in erecting stacks, and it is not unusual for them to erect a 95-foot by 66-inch guyed stack on a base 20 feet high in 15 hours. This includes driving the rivets cold and painting the stack.

The Ahern Boiler.

Of recent years manufacturers of all classes of steam boilers have been making improvements in construction tending towards economy and efficiency. It is claimed that much has been accomplished in this direction in the Ahern steel boiler herewith illustrated. The inventor, Mr. D. Ahern, 263 South street, New York City, has in the past forty years been actively engaged in the manufacture of all kinds of steel boilers and auxiliaries, being one of the first to make the Neil W. MacIntosh water-arch and feed-water heater—a steel water-arch which is extensively used in up-to-date boiler plants throughout the country. For marine repair work, Mr. Ahern is held in high regard by the marine engineers of New York, especially by those who have entered this port with a ship in a crippled condition and who wished to have repairs made quickly and permanently.



SIDE AND END ELEVATION OF THE AHERN BOILER.

The Ahern boiler is so constructed that not a single rivet in its general construction comes in contact with the fire; in other words, the fire-box is entirely free from rivets. Too much stress cannot be placed upon this point of merit in any boiler, as it is sure to minimize the possibility of leaks.

As shown in the illustration, the boiler has a complete mass of tubes crossing each other over the fire at an angle of 45 degrees. From the grate the gases pass through the boiler by the set of tubes in one direction, thence from the top of the shell down through the side damper to a second set of tubes over the second furnace. After passing through these tubes, the gases pass into the up-take, thus a large amount of gas travel is obtained through straight tubes.

By means of the double firing compartment, the power of the boiler may be readily increased. When both grates are used, means are provided for the regulation of the flow of the gases by means of side dampers. The peculiar shape of the boiler over the furnace prevents the accumulation of sediment over the fire as the slope of the crown sheet is such as to bring all the sediment into the water-leg below the action of the fire, where it can be readily blown off through the blow-off pipe. A careful study of the action of suspended matter in water over the heated crown sheet of a boiler will convince any engineer that danger from this source should be eliminated if possible.

On account of the large amount of heating surface in this boiler, and the small space which it occupies for a given horsepower, it is especially adapted for marine work.

Steel Rivets.

Just twelve years ago this coming April the Champion Rivet Company, of Cleveland, Ohio, started in a very small way to manufacture steel boiler rivets, which at that time were looked upon with a great deal of suspicion on account of the prejudice existing against the use of steel for this purpose. This was about the time of the inception of basic open-hearth steel, the quality of which was not well known in this country. So convinced were this company of the adaptability of this steel for all purposes where the best Norway iron had been used, that they persevered in their effort and increased their business year after year until this year they are moving into one of the largest and best equipped rivet manufacturing plants in the world. A bird's-eye view of this plant was shown on the front cover of the February BOILER MAKER. All machinery will be electrically driven, the power being generated by a battery of four boilers and a 700-horsepower engine and dynamo. A large electric crane will handle material from the cars into stock piles, and special conveyors will carry the rivets away from the machines. The boilers were furnished by the D. Connelly Boiler Company, the engine by Hooven, Owens & Rentschler Company, the electrical apparatus by the Westinghouse Electric & Manufacturing Company, and the cranes by Pawling & Harnischfeger, and the Case Manufacturing Company.

The plant is located on a 23-acre plot of ground, and the buildings cover an area of about 4½ acres. The company of which Wilson B. Chisholm is president, David J. Champion, vice-president and general manager; Henry Chisholm, secretary and treasurer, and Matthew Champion, general superintendent, expect to begin operations in the new plant April 1 next, with a capacity of upwards of 250 tons per day. The product of the concern, the Victor boiler rivets, are well known by almost every consumer of rivets in the country.

Western River Steamboat Boilers.

The type of boiler which is in most general use on our western river steamboats is the plain cylindrical return flue boiler. High steam pressures have always been used on these boats on account of the slow-speed, long-stroke engines which are used to drive the stern paddle wheels with which this type of craft is invariably fitted. On account of the high steam pressures the boilers are usually of small diameter. Three or four of them are usually installed in a single battery in a manner similar to that shown in the accompanying illustrations. These views show the boilers installed on the river packet *S. S. Brown*, a steel hull boat, which was built in 1906 by James Rees & Sons, at Pittsburg, Pa., for the Memphis and Vicksburg division of the Arkansas River Packet Company.

The *Brown* has four boilers, each 44 inches in diameter and 24 feet long. Each boiler has six flues, the three upper ones being 10 inches in diameter and the three lower ones each 8 inches in diameter. The shell plates are of steel of 65,000 pounds tensile strength, 0.28 inch in thickness. All girth seams are single riveted and all longitudinal seams are double-riveted lap joints. The flues are made in sections which are riveted together. There is a common steam drum placed at right angles to the length of the boilers on top, and two mud-drums, one at either end, underneath. The location of these is shown in Fig. 1.

The boilers are placed well forward on the main deck of the boat, with the furnaces at the forward end, and they are not enclosed since the entire deck with the exception of the engine room at the after end is left open and free for carrying freight. An iron casing which is lined with ¼ inch of asbestos, upon which firebrick is set, surrounds all four boilers up to a height just above the flues. This casing serves to confine the hot gases which pass back under the boilers and then forward again through the flues. Fig. 2 shows the cast-iron furnace front and uptakes. Besides the regular fire doors there are small poke-hole doors underneath each boiler to assist in stoking the fires. The uptakes lead to two stacks, each 60 feet high above the grate bars, one on each side of the boat.

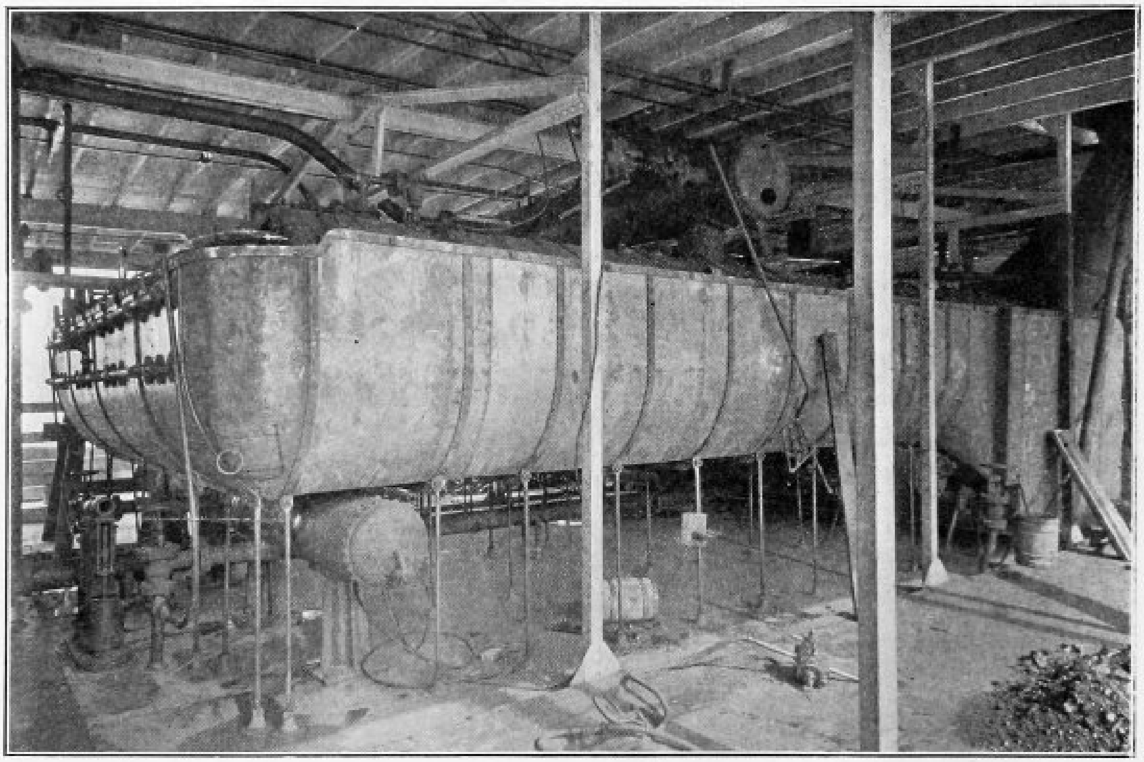


FIG. 1.—SIDE VIEW OF THE BOILERS ON THE WESTERN RIVER PACKET, S. S. BROWN.

The allowable working pressure is 165 pounds per square inch. The total heating surface of the four boilers is about 2,400 square feet, and the total grate area is 70 square feet, making a ratio of heating surface to grate area of a little over 34. Under normal conditions natural draft is used, but for cases of emergency steam blowers have been fitted in each of the flues at the back of the boilers, by means of which forced draft can be obtained. The arrangement of these blowers is shown in Fig. 1.

The regular supply of coal on this boat is carried in the two forward holds. The hatches leading into these holds are directly in front of the furnaces and are fitted with elevator boxes so that the boilers may be fired directly from the elevator boxes.

Strength of a Double-Strapped Butt Joint.

1. Taking rivets in single shear at 38,000 pounds a square inch and in double shear at 70,300 pounds a square inch of section, give the analysis of a double-strapped butt joint having, on the narrow strap two rows of rivets in double shear, and, on the broad strap, a third row of rivets in single shear and double pitch. The plates are ⅜ inch and the straps 5-16 inch thick, the tensile strength of the plate is 60,000 pounds, the diameter of the rivet holes is 13-16 inch, single pitch is 3.25 inch and double pitch is 6.5 inches.

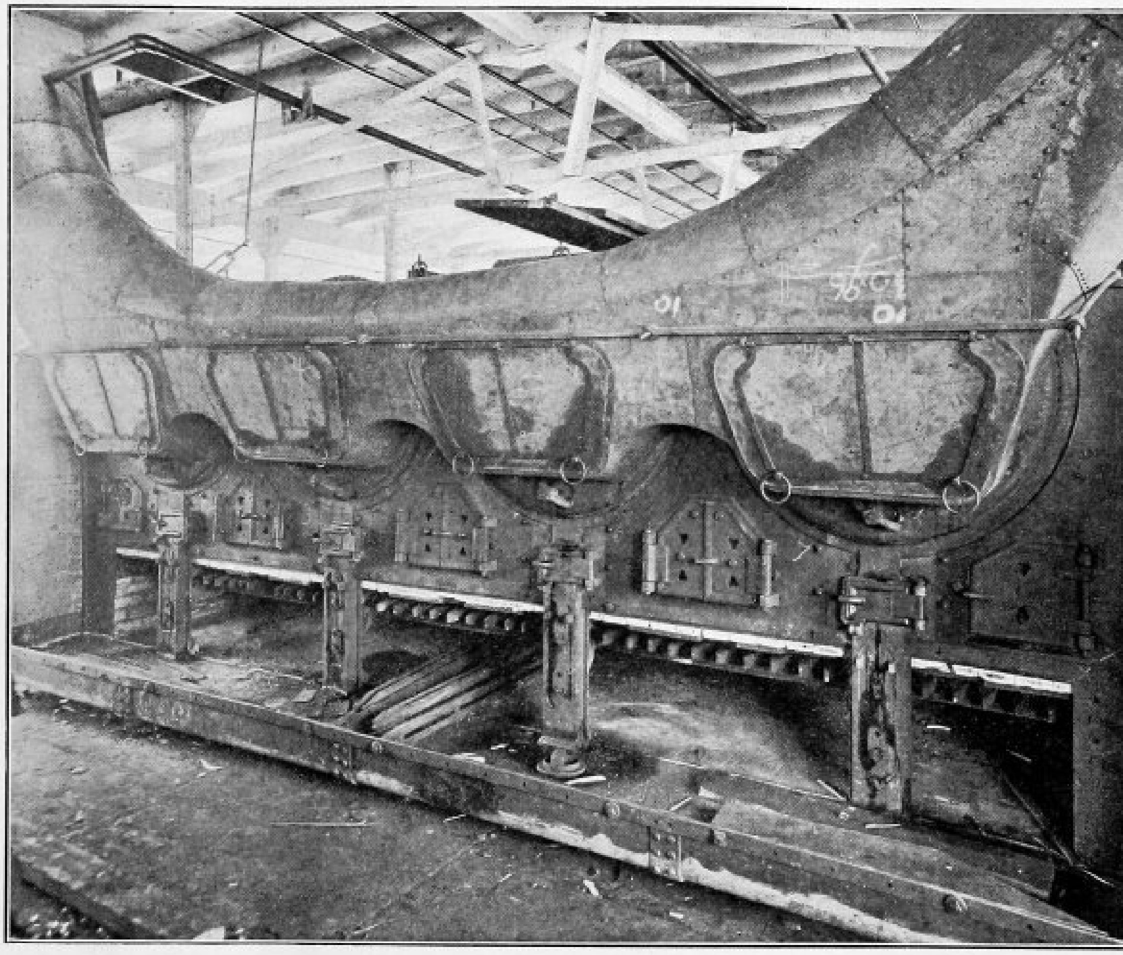


FIG. 2.—FURNACES AND UPTAKES OF THE BOILERS ON THE S. S. BROWN.

2. What is the allowable pressure on a boiler flue 18 inches in diameter and 12 feet long, built in two 6-foot sections of 5-16-inch steel and having the seams single riveted?

3. In a locomotive boiler, with fire-box plates of 5-16-inch steel and stay-bolts ⅞ inch in diameter at the top of the thread and pitched 5 inches apart, what will be the allowable pressure with regard to the stay-bolts?

4. With circular fire-boxes 36 inches in diameter, made single-riveted of 5-16-inch steel, what pitch and size of stay-bolts should be used for 100 pounds pressure?

Ans. 1.—On one side of a butt joint, the total shearing resistance of the rivets should equal the tensile strength of the plate through the line of rivet holes farthest from the joint line. The tensile strength of a butt strap through the line of rivet holes nearest the joint line should equal the strength of the plate through the line of rivet holes farthest from the joint.

In triple or quadruple-riveted straps, the alternate rivet should be left out in the rows nearest to and farthest from the joint line, provided that there is sufficient shearing strength of the rivets and provided that the joint is not to be water tight. If the butt is to be water tight, only the alternate rivet in the row farthest from the joint should be left out. The strength of a riveted joint cannot exceed the strength of the riveted plate through the line of rivet holes farthest from the joint.

Let: d = diameter of the rivets in inches.

p = pitch of the rivets in inches.

t = thickness of the plates in inches.

T = tensile strength of the plates in pounds a square inch.

n = the number of rivets in single shear.

n_1 = the number of rivets in double shear.

S = single shear resistance of the rivets in pounds a square inch.

S_1 = double shear resistance of the rivets in pounds a square inch.

If the joint is properly designed, the rivets will be on the point of shearing when the plate is on the point of tearing and the shearing resistance of the rivets in pounds must equal the strength, along the lines of rivets A A in the figure, of a strip of the plate having a width $2p$. All of the rivets have a common cross-sectional area which is $0.7854d^2$. For the rivets in single shear the total shearing resistance in pounds a square inch is $n\ S$ and for those in double shear is $n_1\ S_1$. Adding these together and multiplying by the area of the rivet cross-section, the result is $0.7854d^2\ (n\ S + n_1\ S_1)$ which is the total shearing resistance of all the rivets in pounds and is equal to the strength of the plate along the line of rivets A A. For the length $2p$ along this line deducting the diameter of one rivet hole, the length of plate that bears the stress is $(2p - d)$ which multiplied by the thickness t gives the area in square inches of the section of the plate under stress. Multiplying this by the tensile strength T of the plate, the result is the strength of the plate to resist rupture so that the equation is:

$$0.7854\, d^2\, (n\, S + n_1\, S_1) = T\, (2p - d)\, t \qquad (1)$$

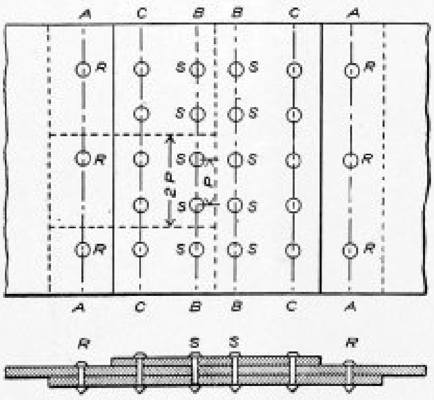
Transposing the quantities in this equation and putting it in form to solve for the pitch of the rivets the result is:

$$p = \frac{0.7854\, d^2\, (n\, S + n_1\, S_1)}{2\, T\, t} + \frac{d}{2} \qquad (2)$$

By a similar transposition this equation can be used to find values for d or t.

Triple riveted butt joints such as that shown in the figure may be broken in five different ways and in each of these the stress in pounds on a length $2p$ that will break the joint as follows:

First—The plate may break through the line A A and in this case the force required is found by multiplying the effective area, $t\ (2p - d)$ by the tensile strength, T of the plate, as



DOUBLE-BUTT STRAPPED JOINT.

was done for the second member of equation (1). Using the figures of the question the result is:

$$Tt\ (2p - d) = 60{,}000 \times \frac{3}{8}\ (6\tfrac{1}{2} - \frac{13}{16}) = 127{,}960 \text{ pounds.} \qquad (3)$$

Second—The straps may break through the line B B, and, in this case, since the straps are 5-16 and the plates 3/8 inch thick, the thickness to be used is 5-6 t. There are two straps and two rivet holes punched from the metal of each strap so that the total effective area to withstand the stress is $2\ (5\text{-}6\ t \times (2p - 2d)$ and this multiplied by the tensile strength gives the total resistance of the straps against rupture which in figures is

$$2\ (\frac{5}{6}\ t\ )\ T\ (\ 2p - 2d) =$$

$$2 \times \frac{5}{6} \times 60{,}000 \times \frac{3}{8} \left(6\tfrac{1}{2} - \frac{13}{8} \right) = 182{,}800 \text{ pounds.} \qquad (4)$$

Third—The plate may break through the line C C and shear the rivet R, in which event, since there are two rivet holes in the plate along the line $C C$, the resistance of the plate is $T\ t\ (2p - 2d)$ and the resistance of the rivet R is its area $0.7854\ d^2$ multiplied by the single shear resistance S in pounds a square inch. Adding together the two separate resistances and taking the figures given, the result is:

$$T\, t\, (2p - 2d) + 0.7854\, d^2\, S = 60{,}000 \times \frac{3}{8}$$

$$(6\frac{1}{2} - \frac{13}{8}) + \frac{0.7854 \times 169 \times 38{,}000}{256} = 129{,}380 \text{ pounds.} \qquad (5)$$

Fourth—The butt straps may break through the line C C and shear the rivets S S, in which case the expression for the strength of the straps is the same as the first member of equation (4) above, and the shearing resistance of the two rivets is the cross-sectional rivet area multiplied by the double shear resistance S_1 so that the total strength to resist rupture in this manner is:

$$2\ (\frac{5}{6} t)\ T(2p - 2d) + 2 \times 0.7854\ d^2\ S^1 = 10 \times$$

$$60{,}000 \times \frac{3}{8}(6\tfrac{1}{2} - \frac{13}{8}) + \frac{2 \times 0.7854 + 169 \times 70{,}300}{256} = 212{,}560 \text{ pounds.}$$

Fifth—All of the rivets may shear on one side of the joint, in which case the expression for the shearing resistance is the same as the first member of equation (1), and since, in this case, $n = 1$ and $n_1 = 4$, the result is:

$$0.7854\ d^2\ (n\ S + n_1\ S_1) = \frac{0.7854 \times 169}{256} \times$$

$$(38{,}000 \times 4 \times 70{,}300) = 163{,}800 \text{ pounds.}$$

In all of these equations the length $2p$ is taken for analysis because it embodies all the features of the joint, or, in other words, each successive length of $2p$ is a repetition of the preceding.

2. In the formulas that follow, the notation is:

p = pressure in pounds a square inch.

T = tensile strength of material in pounds a square inch.

t = thickness of the plate in inches.

f = factor of safety.

d = diameter of the flue in inches.

L = length of the flue in feet.

For finding the safe external pressure on a boiler flue, authorities agree that, of all the empirical formulas in use, the one given by Nystrom used with the factor of safety 4, agrees most nearly with the results of experiments on the resistance of flues to external collapsing pressure. This formula is:

$$p = \frac{4\, T\, t^2}{f\, d\quad L} = \frac{4 \times 60{,}000}{4 \times 18 \times 3.46} \times \frac{25}{256} = 94.1$$

pounds a square inch, which is the allowable external pressure on a boiler flue of the dimensions given.

Clark gives the formula,

$$p = \frac{200{,}000\, t^2}{d^{1.75}} = \frac{200{,}000 \times 25}{18^{1.75} \times 256} = 124.1$$

pounds a square inch.

Lloyd's *Register* and the rules of the Board of Trade prescribe further that in no case must the external pressure exceed the amount given by the formula:

$$p = \frac{8{,}000\ t}{d} = \frac{8{,}000 \times 5}{18 \times 16} = 138.8$$

pounds per square inch.

For a new boiler or one where the stays are in good condition and the plates are not corroded, the pressure found by Clark's formula is safe.

3. Rule 2, Section 6, of the rules of the United States Supervising Inspectors provides that no stays or braces employed in the construction of boilers shall be allowed a greater strain than 6,000 pounds a square inch of net section.

Taking stay-bolts having an external diameter of 7/8 inch, the diameter at the bottom of the threads will be about 13-16 inch. This gives a cross-sectional area of 0.51 square inch, which, multiplied by 6,000 and divided by the square of the pitch of the stay-bolts—25, gives 122.4 pounds as the allowable pressure with regard to the stay-bolts.

For the relation between the thickness of the plate and the diameter of the stay-bolt, use the formula:

$$\frac{d \times 70}{p} = D = \sqrt{\frac{t^2 \times 9^2}{p}}$$

where, d = the diameter of the bolt,
t = the thickness of the plate in 16ths,
p = the allowable working pressure,
and D = the pitch of the bolt.

Using this formula and the values given in the question, the allowable pressure on the bolt is 144 pounds, but for the plate it is only 92 pounds. In a properly constructed boiler, there should not be this difference between the pressure found for the plate and that found for the stay-bolt, but, so long as the conditions are recognized, the extra size of the stay-bolt in proportion to the thickness of the plate will have the advantage of being a safeguard against corrosion.

4. The United States rules provide that circular flues and boxes shall be supported by stay-bolts under the same rules as are provided for the staying of flat surfaces. Having given the thickness of the plate and the pressure to be used, the size and pitch of the stay-bolt is figured from the formula given in the last paragraph. With the plate 5-16 inch thick and a pressure of 100 pounds, the pitch is 4.79 inches and the diameter of the bolt is 0.69 inch.—*Engineer*.

Elementary Problems in Laying Out.

THE LAYOUT OF ANGLE-IRON RINGS.

Where it is necessary to bend bars of angle-iron into the form of a circle or ring in order to fit around a circular tank or pipe, it is a much easier and quicker job to lay out the bars and punch the rivet holes before the iron is bent. This can be done very accurately, and is by no means a difficult job of laying out. It is necessary, however, to know some rule by which the exact length of the bar may be obtained, so that when it is bent either the inside or the outside diameter of the ring, depending upon whether it is an inside or outside angle, will be the required amount.

There are two good working rules which may be used and will apply equally well whether the bar is bent cold or hot. For an outside angle, that is, with the heel of the angle toward the center of the circle, the diameter to be used in computing the length of the bar will be as follows: Using the figures indicated in Fig. 24, and calling the inside diameter of the ring D, then the proper diameter to use will be

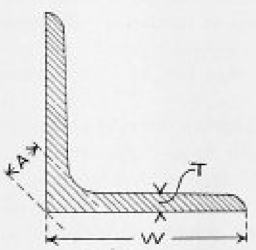


FIG. 24.

$$D + 1/3\, W + T.$$

That is, it is the inside diameter of the ring plus one-third the width of the angle plus the thickness of the angle measured at the line of rivet holes. The length of the bar will, of course, be this diameter multiplied by 3.1416. For an inside angle, if D equals the outside diameter of the ring, the diameter to be used for computing the length should be

$$D - (1/3\, W + T).$$

The length will, therefore, be 3.1416 times this amount.

Another good working rule is as follows: For outside angles the diameter to be used in computing the length should be $D + 2A$ where D is the inside diameter of the ring and A is the thickness of the root of the angle measured diagonally as indicated in Fig. 24. For inside angles, if D is the outside diameter of the ring, then the diameter to be used in computing the length should be $D - 2A$.

Some small allowances are frequently made, due to the stretch in the bar caused by punching the holes, but this is best determined by observation, as no definite allowance can be stated. It would be small at most. The bars may be bent to a comparatively short radius after the holes have been punched without tearing the metal from the rivet holes to the edge of the bar, or destroying the shape of the holes, by inserting in the holes the small pieces which have been punched out. These will tend to keep the holes perfectly round, and the small pieces may easily be knocked out after the bar is bent.

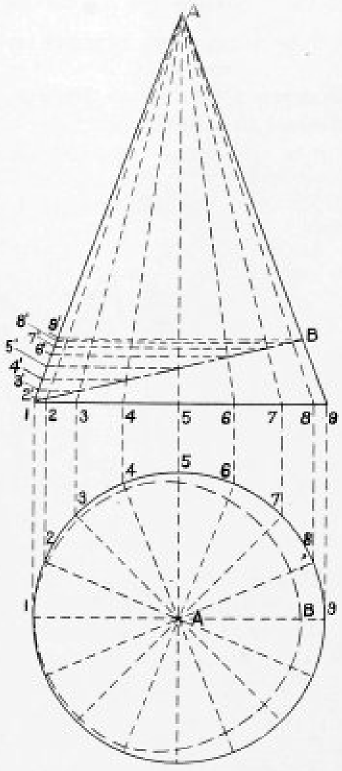


FIG. 25.

CONICAL SURFACES.

Conical surfaces may be developed by a method somewhat similar to that used with cylindrical surfaces. A cross section of the cone is divided into a number of equal parts, and lines are drawn on the surface of the cone from these points to the vertex. For instance, in Fig. 25 the circumference of the base of the cone is divided into sixteen equal parts, and lines are projected from these points of division to the base of the cone in the elevation. These points are then connected with the vertex of the cone A. It may then be seen that the surface is divided into a number of triangles, the sides of which are elements of the cone, and therefore equal to the distance $A1$, and the bases equal to the length of the equal divisions shown in the plan, that is, the distances 1-2, 2-3, 3-4, 4-5, etc. This side of the triangle is, of course, the arc of a circle since each point in the circumference of the base is equidistant from the vertex of the cone A. The circumference of the base of the cone, when laid out in the development, will then be the arc of a circle drawn with radius $A1$. This development is shown in Fig. 26.

If the base of the cone had been inclined, as shown by line $1B$ in the elevation of Fig 25, it would be necessary to lay out the development as shown by the outline in Fig. 26, and then measure the length of each of the elements which have been drawn on the surface of the cone from the point *A* to the base 1*B*. It will be noted that in the elevation, Fig. 25, the true length of only two of these elements is shown, that is, the elements *A*1 and *AB*. The length of the remaining elements may be found by projecting the points at which the line 1*B* cuts the lines *A*-2, *A*-3, *A*-4, etc., over to either the line *A*-1 or *A*-9, and then measuring the distances *A*2', *A*3', *A*4', etc. These distances have been laid off on the corresponding lines in Fig. 26, locating the dotted line 1-9'-1, which is the development of the circumference of the inclined base of the cone 1*B*.

THE INTERSECTION OF A CONE AND CYLINDER AT AN ANGLE OF 60 DEGREES.

In Fig. 27 is shown a cone connecting a 2-foot with a 4-foot pipe. The 2-foot pipe branches from the larger one at an angle of 60 degrees. The end elevation shows that the sides of the connection are tangent to the cross-section of the large pipe. The problem is to find the development of the conical connecting piece and the section of 4-foot pipe which it intersects.

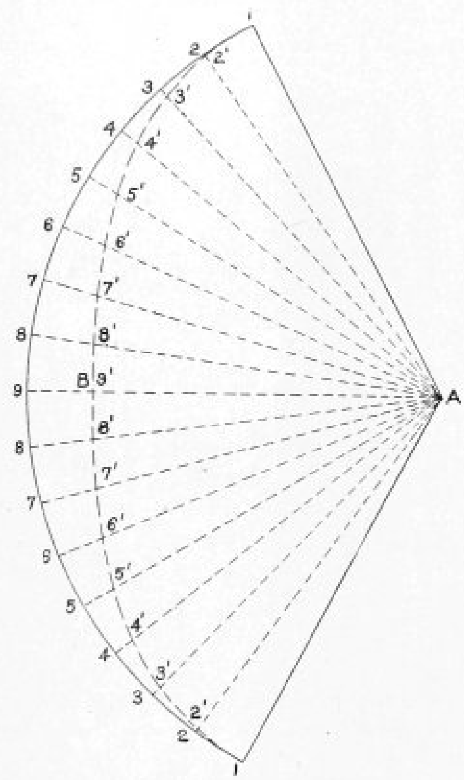


FIG. 26.

The construction, by means of which this is done, is shown in Fig. 28. This is shown at a larger scale for the sake of clearness. Produce the sides 4*c* in the end elevation until they intersect at the vertex of the cone *A*. Project this point over to the side elevation and the point where the horizontal line *A A* intersects the axis of the branch pipe will be the side elevation of the vertex. Take a cross-section of the cone through the line 4-4 in the side elevation. The diameter of this section is the distance 4-4. Draw *B C* in the side elevation perpendicular to *A*-4 through the point 4, making it equal to the length of the diameter 4-4. Connecting *B* and *C* with *A* gives the outline of the side elevation of the cone.

On *B C* as the diameter draw a half view of the cross-section of the cone, and divide it into six equal parts. A greater number of divisions should be taken in actual practice, but only six were used in this problem to avoid confusing the figure. Project these points of division to the line *B C* and connect the latter points with the vertex *A*. Since the axis of the cone in the end elevation is inclined downward and backward, in order to draw the equally spaced elements in this view, it will be necessary to revolve the cone about the vertex *A* until the axis is vertical or in the position indicated by the dotted lines *A M N* in the side elevation. The cross-section of the cone through 4-4 will then be represented in the end elevation by the line *S T*, which may be divided in a similar manner to the line *B C*. The points of division should then be projected upward until they intersect horizontal lines drawn from the corresponding points on the line *B C* in the side elevation. This will give the end elevation of the cross-section of the cone in the inclined position. This is shown by the dotted ellipse. Join the points thus found in the cross-section with the vertex *A*. In Fig. 28 the elements on the front of the cone are shown to the left of the center line and those on the back are shown to the right in order to avoid confusion in the figure.

Number the points where these lines intersect the circumference of the 4-foot pipe in the end elevation 1, 2, 3, 4, 5, 6 and 7; then project these points to the corresponding elements drawn on the surface of the cone in the side elevation, thus locating the line of intersection between the cone and the large pipe.

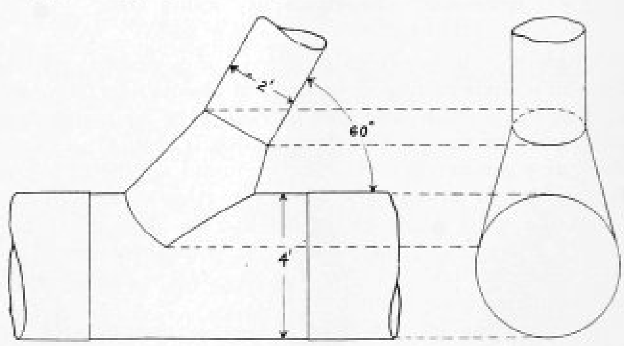


FIG. 27.

Having obtained this line of intersection, the cone may be developed in the usual way. The half pattern of the cone is shown just at one side of the side elevation. The arc *B' C'* is made equal in length to half the circumference of the cross-section *B C*. *B' C'* is then divided into the same number of equal parts as the semi-circumference of the cross-section, and these points are connected with the vertex *A*. The top edge of the connection is the arc of a circle, whose radius is *A* a. The bottom edge of the connection is found by projecting the points 2, 3, 4. 5 and 6 to the line *A B* and then by laying off along the corresponding lines in the development the distances measured from *A* to these points.

The development of the section of large pipe intersected by the cone is shown in Fig. 29. The width of the plate *R H* corresponds to the line *R H* in Fig. 28. The length of the plate *R O* is made equal to the circumference of the pipe, *i. e.*, of a circle 4 feet in diameter. Square up the plate and locate the center line 8-1; then on either side of 8, the distances 8-9, 8-10, 8-11, 8-12 and 8-13 are laid off equal to the distances 1-7, 1-2, 1-6, 1-3, 1-5 and 1-4 in the end elevation, Fig. 28. The distance 8-7 measured from the side elevation, Fig. 28, is then laid off along the line 8-1. Similarly the distances 9-6, 9-5, 9-4, 9-3, 9-2, 9-1, measured from the side elevation, are laid off on their respective lines as indicated by the numbers. A smooth curve through these points is then the developed line of intersection. The proper amount for laps and flanges should of course be added on both patterns, the amount depending on the thickness of material, size of rivets, etc.

Annual Meeting of the Board of Supervising Inspectors, Steamboat Inspection Service.

At the annual meeting of the Board of Supervising Inspectors of the Steamboat Inspection Service, recently held in Washington, D. C., Capt. Ira Harris, of New York, supervising inspector of the second district, presented the following recommendations relative to the requirements for castings of steel, iron, malleable iron, composition, semi-steel and ferro steel for fittings of boilers, steam and water pipes subject to steam pressure.

1. All fittings of cast metal, except those of composition, must be thoroughly annealed.

2. Fittings of steel, malleable iron, composition, semi-steel and ferro-steel can be used of any size not exceeding 3 inches.

3. Fittings of composition must not be used where by reason of steam being superheated the temperature is over 350 degrees F.

4. Fittings of cast iron, malleable iron, semi-steel and ferro-steel above 3 inches, must be tested by manufacturer and the pressure applied and identifying trade mark or name stamped on each casting. When so stamped they can be used, provided the stamped pressure is three and one-half times the steam pressure allowed.

5. Fittings of steel made by regular process and reputable makers who guarantee the castings to possess the chemical and physical characteristics below, and stamp same with their trade mark or name, may be used in all fittings coming under this heading:

Tensile strength	minimum	60,000	pounds.
Elastic limit	"	30,000	"
Elongation in 2 inches	"	25.	percent.
Phosphorus	maximum	.045	"
Sulphur	"	.035	"
Silicon	"	.50	"
Carbon	"	.40	"
Carbon	minimum	.20	"

6. Boiler makers, ship builders and others having stocks of unstamped castings can have same tested and stamped by the boiler inspectors instead of manufacturers.

In his report, Captain Harris calls attention to the reasons for making the above changes in the physical and chemical characteristics of steel castings. It was recommended that the minimum tensile strength be reduced from 62,000 to 60,000 pounds, in order to make the physical tests less severe than the chemical tests, so that if a heat shows that it has the chemical requirements the maker will know that the product will stand the physical test. Since ductility is fully as well shown by elongation as by reduction of area, and, furthermore, since elongation is much more easily determined than reduction of area, the latter test has been omitted.

The percentages of phosphorus and sulphur allowed have been raised from .04 and .03 to .045 and .035 on account of the difficulty of obtaining American pig iron sufficiently low in these elements. Since the Navy specifications of .05 for both phosphorus and sulphur were made, great advance has been made in the art of steel casting. The committee also deemed it necessary to guard against excessive silicon be-

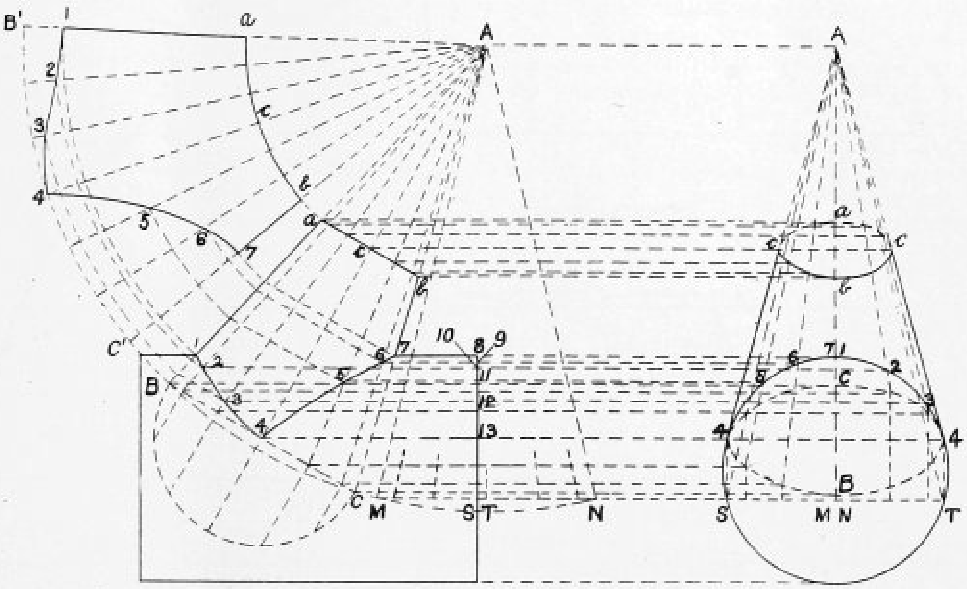


FIG. 28.—SIDE ELEVATION AND DEVELOPMENT OF CONE. END ELEVATION.

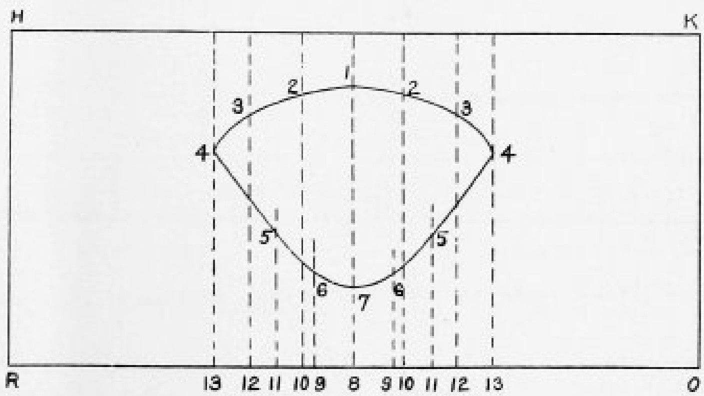


FIG. 29.

cause a number of malleable castings which have failed have shown excessive silicon unevenly distributed.

A maximum and minimum limit for carbon was fixed, because, of late, very low carbon steel has been made of high tensile strength, due to excessive manganese.

Layout of a Tank, 85 Feet in Diameter by 30 Feet in Height.

Large steel tanks are seldom required to carry any pressure except that due to the head of the fluid which they contain. Therefore, the first thing to do in laying out such a

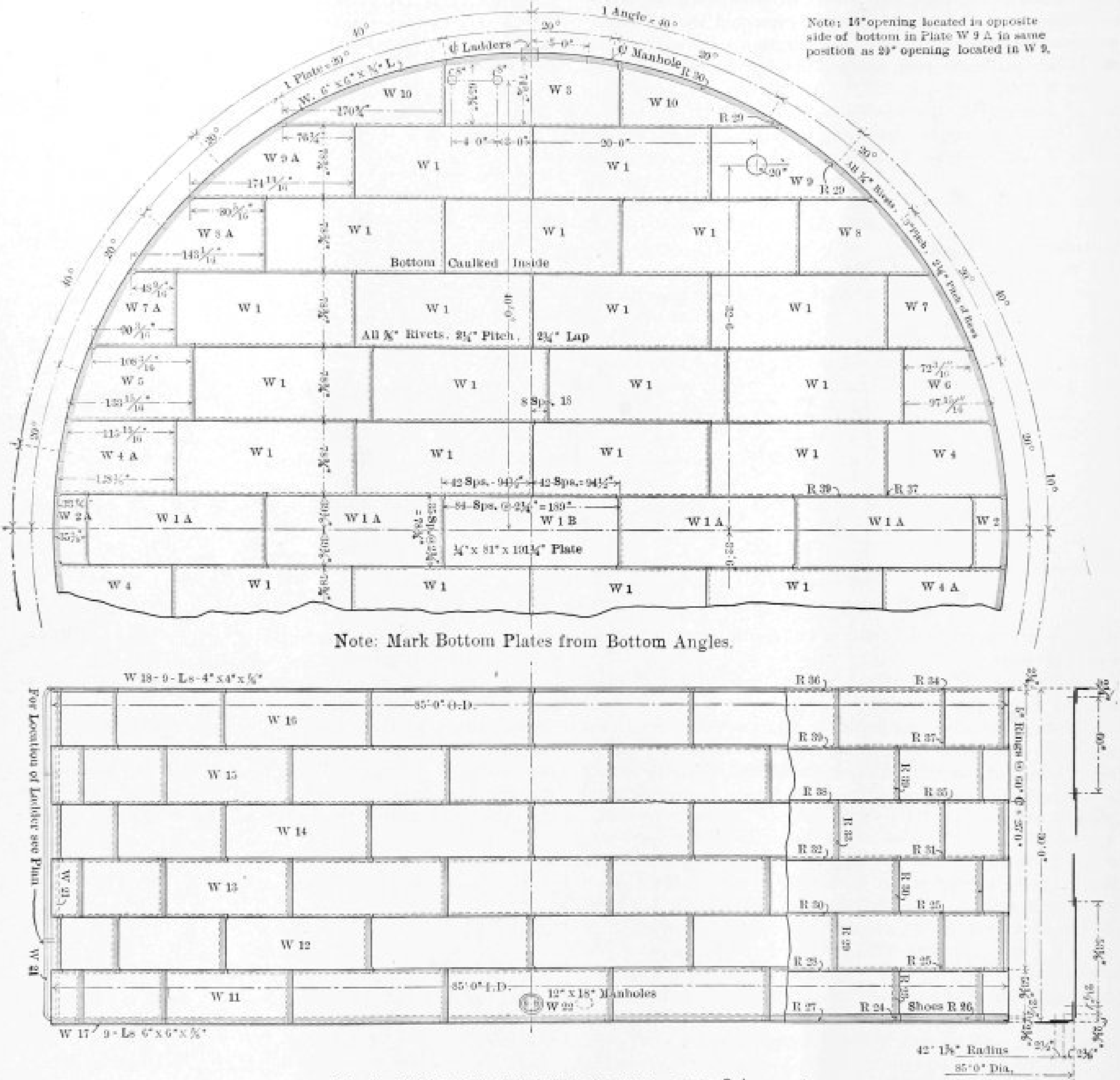


FIG. 1.—PLAN AND ELEVATION OF STEEL TANK 85′ BY 30′.

Of the six requirements quoted above, it is reported at this time that the first five were accepted. Further important changes made by the board will be made known as soon as the official report of the annual meeting is published.

An autogeneous welding plant, the first of its kind in the Pittsburg district, has been installed in the works of the Wm. B. Scaife & Sons Company, at Oakmont, Pa., by the Vollkommer-Reich Company, of Pittsburg, for welding all kinds of sheet and plate work for tanks, boilers, etc. This process of welding plate and sheet metal is considered very economical, especially for butt welding, and is applicable equally for longitudinal, circular or for corner seams.

tank is to determine the stress on the bottom of the shell, due to the head of water, oil, or whatever fluid the tank is to hold. The stress will be greatest, of course, on the bottom of the shell, and the thickness of shell plates may be decreased from the bottom to the top.

Let us assume that the tank is to be used for softening boiler feed-water; that is, the tank must be strong enough so that it may be entirely filled with water. The maximum pressure on the tank will, then, be that due to a head of 30 feet of water. One cubic foot of water at ordinary temperature, 62 degrees F., weighs 62.352 pounds; that is, a head or depth of 1 foot of water will cause a pressure of 62.352 pounds per square foot, or $62.352 \div 144 = .433$ pounds per square inch.

Therefore, a head or depth of 30 feet of water will cause a pressure of $.433 \times 30 = 12.99$ pounds per square inch at the bottom of the tank.

We then have a cylindrical shell 85 feet in diameter with an internal fluid pressure of 12.99 pounds per square inch. The thickness of plate necessary to withstand this pressure may be found by the ordinary formula for finding the thickness of a boiler shell.

If

t = thickness of plate.
p = pressure in pounds per square inch.

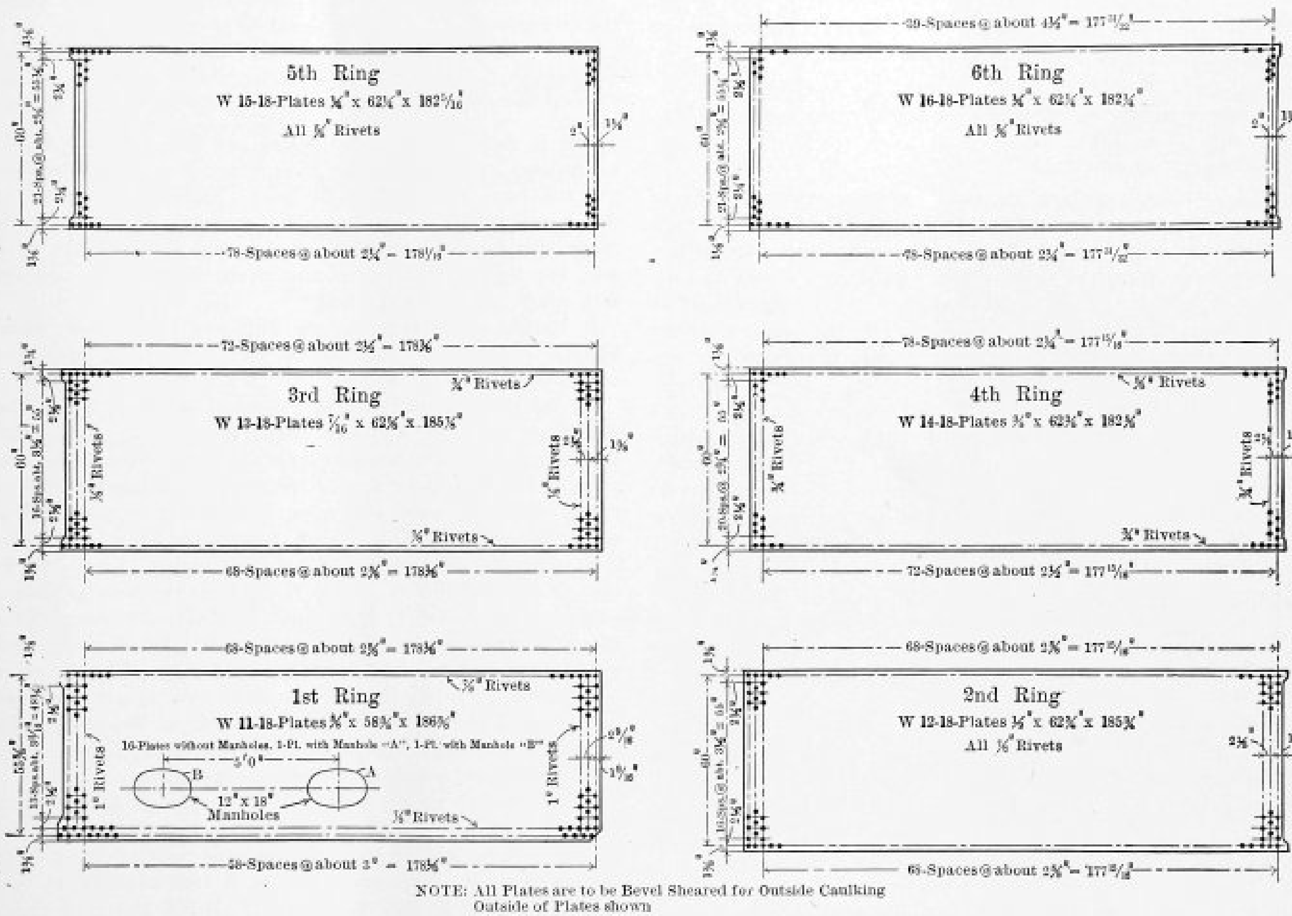


FIG. 2.—DEVELOPMENT OF SHELL PLATES OF STEEL TANK 85′ BY 30′.

D = inside diameter of tank in inches.
F = factor of safety.
Ts = tensile strength of the steel in pounds per square inch.
E = efficiency of riveted joint.

Then
$$t = \frac{p \times D \times t}{Ts \times E \times 2}$$

p in this case we have found to be 12.99. D is 85×12, or 1,020 inches. F may be taken comparatively small, as the pressure on the tank is small, and the wear on the steel will not be excessive; 4 will be a sufficiently large factor to use. Mild steel of a fair amount of ductility should be used; therefore, its tensile strength should be about 60,000 pounds per square inch. If the vertical seams are made with a treble riveted lap joint, an efficiency of 75 percent may be easily obtained. Substituting these values in the formula for the thickness of shell plate, we have

$$t = \frac{12.99 \times 1{,}020 \times 4}{60{,}000 \times .75 \times 2} = .588 \text{ inch.}$$

This is slightly less than ⅝; therefore, use ⅝-inch plate for the bottom course.

As the tank is to be 30 feet high, and plates about 5 feet wide can be easily handled in the shop, make the tank in six rings or courses. Number the rings from bottom to top, 1, 2, 3, 4, 5 and 6. The thickness of plate to be used for the second ring must be computed in the same way in which the thickness of plate for the first ring was found. The pressure on this ring will be that due to a head of 25 feet of water, or $25 \times .433 = 10.825$ pounds per square inch; therefore,

$$t = \frac{10.825 \times 1{,}020 \times 4}{60{,}000 \times .75 \times 2} = .491 \text{ inch.}$$

Use ½-inch plate for this course.

For the third ring, the pressure is that due to a head of 20 feet of water, or $20 \times .433 = 8.66$ pounds per square inch; therefore,

$$t = \frac{8.66 \times 1{,}020 \times 4}{60{,}000 \times .75 \times 2} = .392 \text{ inch.}$$

Use 7/16-inch plate for this course.

For the fourth ring, the pressure is that due to a head of 15 feet of water, or $15 \times .433 = 6.459$ pounds per square inch. As the pressure on this ring is only half of that at the bottom of the tank, the vertical seams may be double instead of treble riveted. The efficiency of the joint will then drop to about 65 percent; therefore,

$$t = \frac{6.459 \times 1{,}020 \times 4}{60{,}000 \times .65 \times 2} = .339 \text{ inch.}$$

Use ⅜-inch plate for this course.

For the fifth ring, the pressure is that due to a head of 10 feet of water, or 10 × .433 = 4.33; therefore,

$$t = \frac{4.33 \times 1{,}020 \times 4}{60{,}000 \times .65 \times 2} = .212 \text{ inch.}$$

On such a large tank it would not be advisable, for structural reasons, to use plate less than ¼ inch in thickness; therefore, make both the fifth and sixth rings of ¼-inch plate.

The approximate pressure on the lower ring, due to the weight of the shell, assuming that 1-inch plate weighs 40 pounds per square foot, will be found as follows:

$$\frac{5\,(25 + 20 + 17.5 + 15 + 10 + 10)}{12 \times .625} = \frac{487.5}{12 \times .625} = 651$$

pounds per square inch.

This pressure is, therefore, small compared with the stress in the plates, due to the internal fluid pressure, so that the shell which has been figured to withstand the fluid pressure with a fairly large factor of safety will be sufficiently strong to support the weight of the tank. The force due to the weight of the tank acts in a vertical direction, while the force due to the fluid pressure acts in a horizontal direction. Therefore, the resultant of the two forces will be slightly larger than the force due to fluid pressure.

Make the width of plates in the five upper rings 60 inches between rivet lines. As the tank is to be 30 feet high over all, the width of the bottom ring will be something less than 60 inches, depending on the width of laps at the top and bottom of the tank. These will be determined when the size of rivets is determined. The length of plates between rivet lines may be made about 15 feet, as plates much larger would be difficult to handle in the shops, and small ones would necessitate an unnecessary number of vertical seams. As our tank is 85 feet in diameter, the circumference is about 267 feet; therefore, if each ring is made of eighteen plates, each plate will be about 14 or 15 feet long between rivet lines. Make the bottom ring an outside ring, then the mean diameter of the ring measured to the center of the thickness of the plate will be 85 feet ⅝ inch. The circumference corresponding to this will be 85,052 × 12 × 3.1416 = 3206.41 inches. Dividing by 18 the length of one plate is found to be 178⅛ inches.

The second ring will be an inside ring, and since the plates are ½ inch in thickness, the mean diameter will be 84 feet 11½ inches. The circumference corresponding to this will be 3202.86 inches. Dividing by eighteen we find the length of one plate between rivet lines to be 177 15/16 inches.

The third ring will be an outside ring, and as the mean diameter is only slightly smaller than the mean diameter of the first ring, the length of the plates may be made the same as for the first ring. Similarly the length of the plates in the fourth ring may be made the same as the length of plates in the second ring. The mean diameter of the fifth ring is 85 feet ¼ inch, making the length of one plate equal 178 1/16 inches. The mean diameter for the sixth ring is 84 feet 11¾ inches, making the length of one plate 177 31/32 inches.

For the vertical seams in the first ring, use 1-inch rivets. The pitch of the rivets may then be determined by making the strength of the net section of the plate equal to the strength of the rivets. The strength of the plate will be $t\,(p - d)\ Ts$. Calling S the shearing strength of rivets in pounds per square inch, the strength of rivets for a treble riveted lap joint will be $¾ \times 3.1416\, d^2\, S$. Assuming S equals 42,000 pounds per square inch or $.7\ Ts$, and equating the strength of plate to strength of rivets we have

$$t\,(p - d) \times Ts = ¾ \times 3.1416\, d^2\ (.7\ Ts).$$

$$p = d + \frac{.75 \times 3.1416 \times .7\, d^2}{t}$$

$$p = d + \frac{1.65\, d^2}{t}$$

$p = 3.64$ inches, or 3 11/16 inches. The pitch of rivets for the vertical seams in the second and third rings will be found in a similar manner, using ⅞ rivets in each case.

As the vertical seams in the fourth ring are double riveted, the strength of rivets will be equal to $½ \times 3.1416\, d^2 \times .7\ Ts$.

$$\text{Therefore, } p = d + \frac{1.1\, d^2}{t}$$

Using ¾ rivets for the fourth ring, we find the pitch equals 2.4 inches. A slightly larger pitch might just as well be used and still have a perfectly tight joint. Increasing the pitch of the rivets simply means that the strength of the rivets is made less than the strength of the plate and that the joint will fail by the shearing of the rivets. Therefore, use 2¾ inch pitch for the fourth ring.

A similar calculation for the fifth and sixth rings, using ⅝-inch rivets gives 2.34 inches pitch. Use 2⅜ for these seams.

As the stress in the shell in a vertical direction, due to the weight of the tank, has been found to be small, all circular seams may be single riveted except the lower edge of the first ring, which should be double riveted. By using the size of rivets ordinarily used with given thicknesses of plate and a sufficiently small pitch to insure a perfectly tight joint, sufficient strength will be obtained for these seams. As the thickness of the first ring is ⅝, use ⅞ rivets in the circular seams, using a 3-inch pitch in the lower double-riveted seam and a 2⅝ pitch in the upper single-riveted seam; ⅞-inch rivets with a 2⅝ pitch may be used for the second ring. The diameter of rivets for the top seam of the third ring may be reduced to ¾ inch, and the pitch to about 2½ inches. Beginning with the top seam of the fourth ring, ⅝-inch rivets spaced about 2¼ inches may be used in the remaining seams.

As the bottom of the tank is well supported, ¼-inch plate may be used with single-riveted seams, ⅝-inch rivets. The plating will be laid in parallel rows using plates of as large size as possible, say, approximately, 6 feet wide by 15 feet long. This will give thirteen rows of plating, eleven of which are 78¾ inches wide between rivet lines, the two outer ones being 74¾ inches wide. A plan of the bottom may be laid out to a small scale, and the lengths of the seams scaled off the drawing, or the length of each seam may be calculated, since it is the chord of a circle whose distance from the center of the circle is known. For if R is the radius of the circle and S the distance of chord from the center of the circle, and L the length of the chord, then

$$(½\,L)^2 = (R + S)\ (R - S)$$

$$L = \frac{\sqrt{R^2 - S^2}}{2}$$

A template made to fit the arc of a circle 85 feet in diameter may be used to obtain the shape of the ends of the outside plates, two points in the curve having been found, viz., the ends of the seams. The butt joints of adjacent plates should never come together. The plan, Fig. 1, shows the arrangement of these plates.

It still remains to lay out the angle-bars which join the shell and bottom, and also the angle-bars which are placed around the top edge of the tanks as stiffeners. As there is to be a double row of $\frac{7}{8}$-inch rivets in each leg of the bottom angle, at least a 6-inch angle should be used, and as the lower shell plates are $\frac{5}{8}$ inch, the angle should be at least $\frac{5}{8}$ inch thick. The length of a 6 inch by 6 inch by $\frac{5}{8}$ inch inside angle bent to an outside diameter of 85 feet, may be found as follows:

If D = outside diameter of ring,
W = width of angle,
t = thickness of angle,

then the length of the ring before bending will be $3.1416\ [D - (1/3\ W + t)]$. Therefore, the length of the bar will be $3.1416\ [85 \times 12 - (6/3 + .625)] = 3196.18''$ or $266.4'$. The ring may be made of nine bars, each bar 29.6 feet long.

Using a 4-inch by 4-inch by $\frac{5}{8}$-inch bar around the top edge of the tank the length of the ring before bending, since it is an outside ring, will be $3.1416\ [85 \times 12 + 4/3 + .625]$, which equals $3211.58''$ or $267.63'$. This ring may also be made of nine bars, making the length of each bar 29.74 feet.

Having determined the sizes of the plates and angles for the tank, the bill of material may be tabulated as follows:

BILL OF MATERIAL FOR I-TANK.

Mark.	No. Required.	Description.
W 1	39	Plates, $\frac{1}{4}$"x81"x191$\frac{1}{4}$".
W 2	2	" $\frac{1}{4}$"x Sketch.
W 3	2	" $\frac{1}{4}$"x "
W 4	4	" $\frac{1}{4}$"x "
W 5	2	" $\frac{1}{4}$"x "
W 6	2	" $\frac{1}{4}$"x "
W 7	4	" $\frac{1}{4}$"x "
W 8	4	" $\frac{1}{4}$"x "
W 9	4	" $\frac{1}{4}$"x "
W10	4	" $\frac{1}{4}$"x "
W11	18	" $\frac{5}{8}$"x58$\frac{3}{8}$"x186$\frac{3}{4}$".
W12	18	" $\frac{1}{2}$"x62$\frac{1}{4}$"x185$\frac{3}{4}$".
W13	18	" $\frac{7}{16}$"x62$\frac{3}{8}$"x185$\frac{7}{8}$".
W14	18	" $\frac{3}{8}$"x62$\frac{3}{8}$"x182$\frac{5}{8}$".
W15	18	" $\frac{1}{4}$"x62$\frac{1}{4}$"x182$\frac{5}{16}$".
W16	18	" $\frac{1}{4}$"x62$\frac{1}{4}$"x182$\frac{1}{4}$".
W17	9	Angles, 6" x 6" x$\frac{5}{8}$"x30' 0".
W18	9	" 4" x 4" x$\frac{5}{8}$"x30' 0".
W19	9	Plates, $\frac{5}{16}$"x12$\frac{5}{16}$"x2' 0".
W20	9	" $\frac{3}{8}$"x 6$\frac{1}{2}$" x2' 0".
W21	2	30' Sections of std. ladder.
W22	2	12"x18" Saddle Plates, Manheads, arches, bolts, cranes, etc., complete.
C 1	1	20" C. I. Gland and calking strip.
C 2	1	16" C. I. Gland and calking strip.
C 3	2	8" C. I. Gland and calking strip.

BILL OF RIVETS FOR I-TANK.

Mark.	No. Required.	Description.
R23	1000	Rivets, 1" diam. x 2$\frac{1}{2}$" Cone Heads.
R24	75	" $\frac{7}{8}$" " x 3$\frac{1}{4}$" " "
R25	300	" $\frac{7}{8}$" " x 3" " "
R26	150	" $\frac{7}{8}$" " x 2$\frac{1}{2}$" " "
R27	2300	" $\frac{7}{8}$" " x 2$\frac{3}{8}$" " "
R28	1200	" $\frac{7}{8}$" " x 2$\frac{1}{4}$" " "
R29	1250	" $\frac{7}{8}$" " x 2$\frac{1}{8}$" " "
R30	4600	" $\frac{7}{8}$" " x 2" " "
R31	150	" $\frac{3}{4}$" " x 2$\frac{1}{2}$" " "
R32	1450	" $\frac{3}{4}$" " x 1$\frac{7}{8}$" " "
R33	800	" $\frac{3}{4}$" " x 1$\frac{3}{4}$" " "
R34	50	" $\frac{5}{8}$" " x 2$\frac{1}{8}$" " "
R35	100	" $\frac{5}{8}$" " x 2" " "
R36	800	" $\frac{5}{8}$" " x 1$\frac{7}{8}$" " "
R37	250	" $\frac{5}{8}$" " x 1$\frac{3}{4}$" " "
R38	1500	" $\frac{5}{8}$" " x 1$\frac{5}{8}$" " "
R39	9500	" $\frac{5}{8}$" " x 1$\frac{1}{2}$" " "

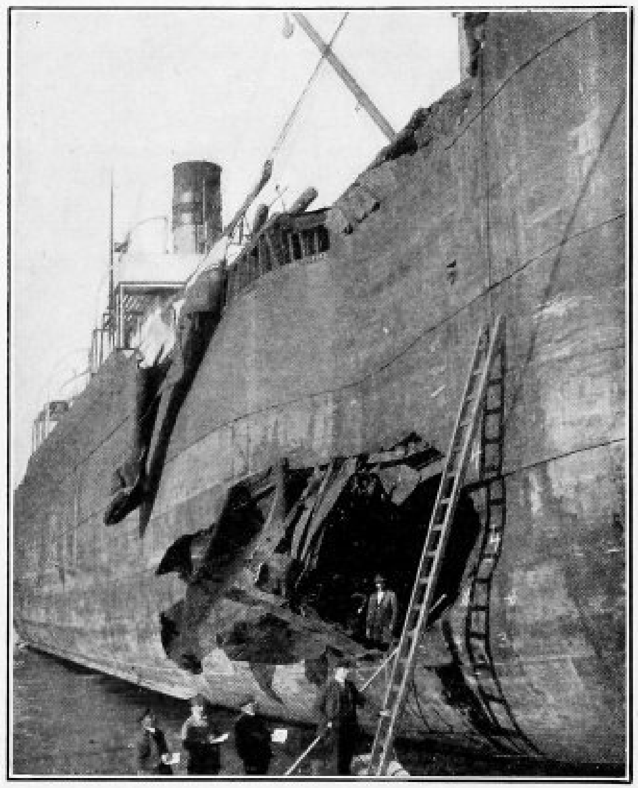
The outside edges of the shell and the inside edges of the bottom should be marked for calking, and the corners of the plates, which come between two other plates, should be marked for scarfing; also the manholes and location of pipe flanges should be indicated, as shown on the drawing, Fig. 1.

The capacity of the tank in gallons may be found as follows: Find the area of the bottom of the tank in square feet, multiply it by the height of the tank in feet, and multiply the product by 7.481, the number of gallons in a cubic foot.

$$\frac{3.1416 \times (85)^2 \times 30 \times 7.481}{4} = 1{,}273{,}530 \text{ gallons.}$$

A Serious Collision.

As illustrating the damage which may be sustained by steel plating, under unusual circumstances, the accompanying photograph is interesting. The Norwegian steamer *Tordenskjold*, Captain Kroger, which was damaged in a collision with the Hamburg-American steamer *Euphemia*, at St. Antoine, some forty miles above Quebec, was



THE TORDENSKJOLD, SHOWING DAMAGE DUE TO COLLISION.

placed on Davie's dock, at Quebec, for temporary repairs. She is a vessel of 335 feet in length and was drawing, at the time of the accident, 23 feet 6 inches. She was on her passage from Sydney, C. B., to Montreal with a cargo of 6,000 tons of coal for the Dominion Coal Company.

The damages sustained by the *Tordenskjold*, as can be seen by the illustration, are very considerable. Besides a large hole on her starboard side, where her plates have been twisted in, all her bulwark is badly torn or dented for a length of about 30 feet from her stem, and all her fore-parts on the starboard side are seriously pounded. In fact, the whole structure of the vessel has sustained considerable shaking up and will require a thorough overhauling.—*Marine Engineering.*

There are just two months in which to submit to us an article on "Heating and Driving Steel Rivets," in competition for the Champion prizes of $50, $35 and $25. Every boiler maker is thoroughly familiar with this subject and should be able to write an interesting article on the various methods of doing such work.

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - New York

Christopher St., Finsbury Square, London, E. C.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico	$1.00	.10
Other countries in Postal Union	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

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 5,800 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

Prizes for Articles on Riveting.

We are authorized by Mr. David J. Champion, vice-president and general manager of the Champion Rivet Company, Cleveland, Ohio, to offer three prizes: the first of $50.00, the second of $35.00, the third of $25.00, for papers on the subject of driving steel rivets.

The question of awarding the prizes will be left to a committee consisting of Mr. M. F. Cole, Newnan, Ga., president of the American Boiler Manufacturers' Association; Mr. C. L. Hempel, Omaha, Neb., president of the International Railway Master Boiler Makers' Association, and Mr. J. H. Smythe, Rogers Locomotive Works, Paterson, N. J., president of the Master Steam Boiler Makers' Association; and should any of these gentlemen be unable to serve authority rests with them to fill any vacancies.

The papers are to cover fully the subject of how to heat and drive steel rivets and make them perfectly tight without calking.

Each paper must divide the subject under different headings, so as to cover the different tools used in driving rivets, viz.: "bull"-driven rivets, pneumatic-driven rivets, and hand or "snap"-driven rivets. Each paper must also consider the best method of heating rivets, whether with natural or forced draft; the most desirable fuel, whether oil, gas, coal or coke; the degree of heat most desirable for the different methods of driving the rivets; the most desirable color of steel; the question of "soaking" rivets too long in the fire at noon or at any other time; the effect of compressed air draft without a fire wall in the furnace, and any other points that have to do with successful riveting.

Those of our readers who are interested in the subject are urged to submit papers on the subject, sending them to THE BOILER MAKER, 17 Battery Place, New York City, and marking them as written in competition for the Champion prize. No name must be signed to the paper, but the author must enclose his name and address in a sealed envelope, which will be marked the same as the paper for purposes of identification, and the authors' names will not be announced until the committee of award has made its report.

All such papers must be in our hands not later than 12 o'clock on Wednesday, the first day of May. This will give the committee plenty of time to go over the papers and award the prizes, which will be announced at the joint convention of the Master Steam Boiler Makers' Association and the International Railway Master Boiler Makers' Association, which is to be held in Cleveland May 21, 22 and 23.

A Suggestion for Layers-out.

In one of the most progressive contract boiler shops in the Middle West, each layer-out keeps a note book in which he makes a sketch of every plate which he lays out. The book has sufficiently large pages so that there is plenty of room for making large clear sketches and placing all the important dimensions upon them. After finishing a job the layer-out makes a note at the top of the page giving the number of the job and a short description of it. He then makes a sketch of each of the plates which have been laid out for this particular piece of work, and draws in the rivet lines, manholes, handholes and other openings or cuts which have been made in the plate. The lengths of the rivet lines are marked, but only the approximate pitch of rivets is given, the exact number of spaces being indicated instead. The size of rivets, thickness of plate and number of plates to be made from that pattern are also given as well as the laps, the distance between rivet lines, etc. Finally, the edges of the plate, which should be planed, and the corners, which should be scarfed, are marked. Thus every bit of information about the layout is given, so that if at any time it is necessary to duplicate the job, the layer-out simply has to refer to his sketches and can find there all the dimensions computed. The duplicate job may then be laid out very quickly, or it may be turned over to an inexperienced apprentice without fear that an error will be made in figuring the size of plate, pitch of rivets, etc.

This method of keeping a record of the work done by a layer-out has many advantages for both the manufacturer and the workman. It is unnecessary for the draftsman to make and keep a great number of blue prints showing the various layouts if it is desired to save them, and at the same time a record of them is kept where it may be most conveniently used by the layer-out. By keeping a set of notes, together with these sketches, the workman can keep track of the allowances which he has made in particular cases, and by measuring the material after it has been bent and forged to shape, he can easily find whether the allowances were too large or too small. By keeping notes of this sort he will soon have accumulated a lot of valuable information as the result of his own observation.

QUERIES AND ANSWERS.

Q.—Given a pipe 28 inches in diameter, intersecting the dished head of a circular tank 6 feet in diameter. The head is dished to a radius of 5 feet 6 inches; the axis of the pipe and tank are parallel, and the pipe is to be flanged to the head. How would the layout of the pipe be obtained?

"KANAKA."

A.—Fig. 1 shows the side elevation and plan view of the tank and pipe. Divide the plan view of the pipe into a convenient number of equal parts (in this case twelve have been

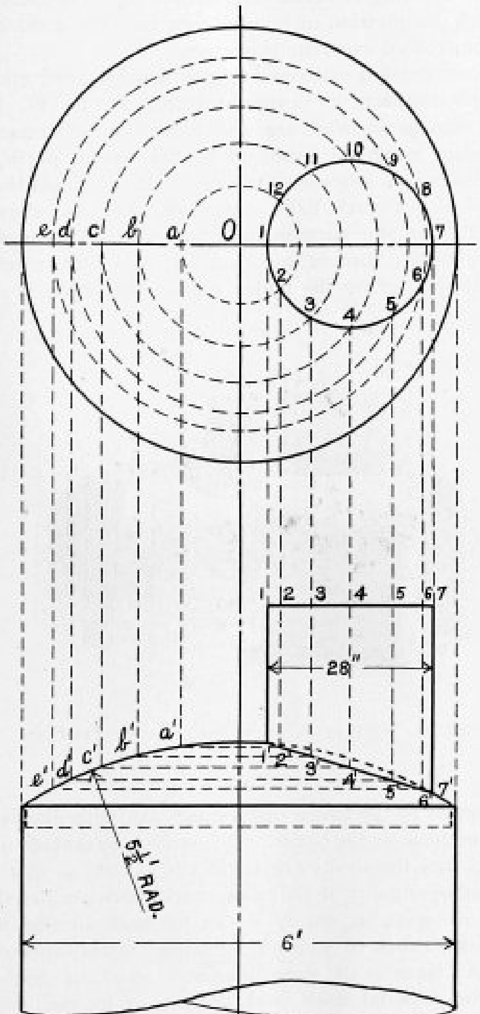


FIG. I.—PLAN AND ELEVATION OF TANK AND PIPE.

taken), and with *O* as a center, describe circles through these points of division as shown by the dotted lines in the plan. From the points *a, b, c, d, e,* where these circles intersect the horizontal diameter of the tank, project lines down to the points *a', b', c', d'* and *e'* on the surface of the dished head in the elevation. From these points draw the horizontal dotted lines *a'* 2, *b'* 3, *c'* 4, *d'* 5 and *e'* 6, which show the elevations of the circles which were drawn in the plan.

From the points 1, 2, 3, 4, 5, etc., where the circles intersect the plan view of the pipe, project lines down to the elevation of the corresponding circles. For instance, since the point 3 in the plan is on the circle *b*3, it will be projected down to the side elevation of the circle, which is *b'* 3', thus locating the point 3', which is one point in the line of intersection of the pipe and head. The points 4', 5', 6', etc., are found in a similar manner.

The development of the portion of the pipe shown in Fig. 1 is given in Fig. 2. The line *AB* is made equal to the circumference of the mean diameter of the pipe, and is divided into twelve equal parts, numbered in the same way as the plan view of the pipe. From these points of division parallel lines of indefinite length are drawn at right angles to *AB;* then

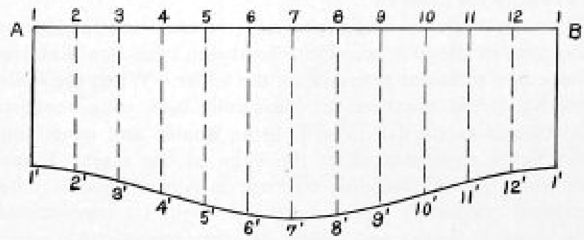


FIG. 2.—DEVELOPMENT OF PIPE.

the lengths of the lines 1-1', 2-2', 3-3', etc., measured from the elevation, Fig. 1, are laid off on the corresponding lines 1-1', 2-2', 3-3', etc., in the development, Fig. 2. A smooth curve is then drawn through the points 1', 2', 3', 4', etc., giving the shape of that edge of the plate.

As the thickness of the material of which the tank and pipe are to be made is not given, the laps and flange have been omitted in the development of the pipe, Fig. 2.

COMMUNICATIONS.

Lap Jointed Longitudinal Seams of Steam Boilers.

EDITOR BOILER MAKER:

The first case that I ever saw of a fractured lap joint of a boiler was in a piece of boiler plate, which had been cut from a 60-inch horizontal tubular boiler. The piece of plate was of Glasgow steel and about 42 inches long by 12 inches wide and ⅜ inch thick. One side had two rows of rivet holes next to the calking edge, and was the outside lap of the double-riveted seam, the length 42 inches being the width of the course, which had been made of two plates to the course. The inside of the plate showed very plainly a fracture which extended nearly the whole width of the course, and near the edge of the rivet farthest away from the calking edge. My judgment would be that the fracture was, at least, two-thirds through the plate. The fracture showed on the outside of the plate a length of about 10 inches.

I was much surprised, and said to a boiler inspector, I wonder what caused that fracture. He replied that the boiler makers abused it in rounding it up. It so happened that that particular boiler was laid out by me, and was rolled up and rounded up as hundreds of others were, in a position where, if I looked up from my work I could not help seeing the rounding up process. The man that we had to do the rolling was a very careful man, and could set his rolls so well as to do almost perfect work. The 4 inches on the end of the plate which the rolls would not take was rounded up with a sledge and hammer. Now, the 4-inch flat plate would receive about ⅛ inch of set or depth of curvature in a circle of 60 inches diameter. Now, when a piece of that same plate could be doubled over cold and hammered down flat on itself, without showing a fracture, I cannot see how the boiler makers could have abused it in rounding up the lap.

I have since seen many broken lap joints, all of which have started from the inside of the plate. I have often wondered why the starting of the fracture from the inside has never been discussed. In your quotation from "Power," "Why the lap joint fails," there is a sentence which reads like this: "The crack in the nature of things develops on the inside." Why is it in the nature of things to develop on the inside? If a piece of boiler plate was being bent to a point of fracture, the fracture, if any, would be looked for on the outer side. My idea of these lap joint fractures is that although the laps may be well rounded up and without injury to the plate, there may be a little too much sweep in the plates near the lap joints, which will tend to make the joint and the adjoining plate flat, as shown by the diagram.

When the boiler is under pressure the shell is rounded out, and is kept in the best position to withstand the strain as long as there is a sufficient pressure on the boiler. When the boiler is relieved from pressure the shell falls back to its original position, and as the lap is stiff, being double and unyielding, the strain is concentrated at the edge of the rivet. I have never known of a lap joint fracture in a new boiler. After a sufficient number of years there is a slight fracture started, which is made longer and deeper at every considerable variation of pressure. That process continues until at the last reduction of pressure the fracture has gone a little deeper, and there is not then left sufficient material to withstand the usual working pressure. Boiler explosions from lap joint fractures most always occur shortly after starting up in the morning, or after the pressure on the boiler has been reduced and then again raised to the usual working pressure.

I would, also, call your attention to another part of your quotation from "Power": "The interior of a butt-strap joint is equally inaccessible to the inspector, but with it the shell can take the true cylindrical form without any tendency to distort the sheet." That is true, but the fact still remains that the flat end of the plate has to be set with a hammer just the same as a lap joint, and consequently is subjected to the same so-called abuse by the boiler maker. The single or double-butt strap may have the same defect as the double-riveted lap joint, that is, there may be a little too much sweep near the joint. The shell plate is gripped tightly between the edges of the inside and outside straps, and by any variation of pressure the strain is concentrated in the shell plate, between the edges of the straps, and crystallization is sure to take place. By having the inside strap extend beyond the outside strap far enough to obtain two or more rows of rivets with a wide pitch, there can hardly be a concentration of strain, therefore, such a joint is much better than the ordinary butt joint with straps of the same width. BOILER MAKER.

ENGINEERING SPECIALTIES.

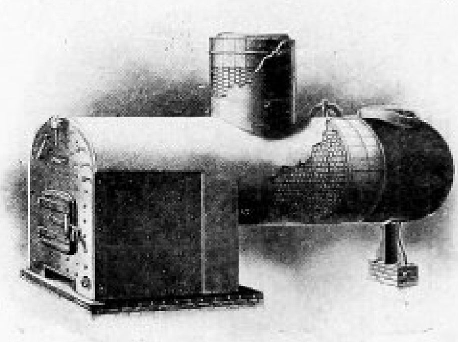
The Insulation of Stationary Boilers.

The marked development in the covering of steam and fire heated surfaces is a subject of universal interest at the present day. Especially is it so to the up-to-date engineer, since no question of steam saving can be settled until the matter of proper insulation is taken into account. Some years ago the subject was of minor importance, and not until pressures began to increase and temperatures to rise did the subject begin to receive attention.

From that time on numerous attempts to prevent radiation by means of covering were made, and although it would seem strange and hard to believe, stable manure was one of the first materials to be used as insulation for steam-heated surfaces. As time went on, however, and as the subject was given more thought and its importance better understood, later attempts to improve upon the materials used were made, and for a time organic matter in the form of animal hair, commercially known as "Hair Felt," was employed. The results obtained from the use of this material, while far exceeding any other that had previously been used, did not solve the problem, as steam pressures were steadily increasing, and, furthermore, it was found that "Hair Felt" became charred and lost most of its non-conducting properties soon after it had been in service. To find a material that would successfully insulate heated surfaces was therefore the problem.

After numerous experiments had been made, it developed that asbestos, a fibrous mineral, could be used to good advantage for this purpose, and accordingly it was made in the form of cement and applied with a trowel. While this was a vast improvement it was found that the material contained two undesirable features, which made it unsatisfactory. The hard and solid nature of the finished work caused it to be a poor non-conductor, and the contraction and expansion of the boiler caused the covering to crack, thus destroying its efficiency. At this period the question of how to overcome these mechanical defects confronted everyone concerned.

After considerable experimenting, which involved great expense and considerable time and labor, the H. W. Johns-Manville Company, who are the largest manufacturers of asbestos and magnesia products in the world, perfected a material, known as asbestos "Fire Felt." It is claimed that this material does not crack, flake or peel off, and it has shown the best results for the purpose by actual test. It is made of floculent asbestos, formed into sheets and so constructed that by slightly moistening the under side of the sheet, it can be



ASBESTOS "FIRE FELT," APPLIED TO A STATIONARY BOILER.

readily applied to the boiler surface and will immediately conform to the shape of the boiler. The peculiar advantage of this material is that the sheets are made 3 by 2 feet, so that there is a minimum amount of joints or cracks between the sheets, and that owing to its nature it can be made in thicknesses varying from 1 inch to 3 inches. Among several other strong points in its favor is the great amount of dead air space confined in the material itself, and because of its resilient and elastic qualities and consequent freedom from damage, when walked on, etc., it is the ideal covering for boiler tops, steam drums, headers and other surfaces too large to be covered with sectional covering.

The manner of application is very simple: the sheets are strapped to the surface to be covered with cable wire, and are held firmly in place with hexagonal netting. Over the surface of these sheets is applied ¼-inch to ½-inch "J-M" asbestos cement, or "J-M" magnesia cement, both of which materials present a hard, smooth and washable finish.

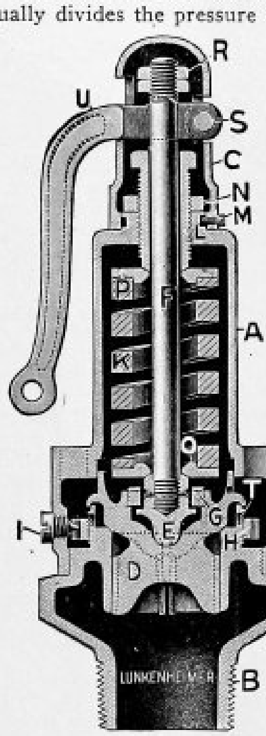
The fire-box is often a source of considerable waste of heat and consequent energy, due to the fact that the brick structure cracks from the intensity of the heat, thus admitting cold air to the fire-box. This is caused by the great difference in temperature between the inner and the outer walls. The use of "Fire Felt" sheets, fastened to the outer surface of the bricks by strap iron or binding rods, will overcome this difficulty. Over the surface of "Fire-Felt" a finished coat of asbestos cement is applied, which has sufficient moisture-repelling properties to enable the surface of it to be washed down and cleaned. This also enables the outer surface to be painted if so desired.

The H. W. Johns-Manville Company, in addition to manufacturing a complete line of materials of this kind, also contract to apply them in any part of the United States.

An Improved Pop Safety Valve.

The Lunkenheimer Company, Cincinnati, Ohio, have lately redesigned their pop safety valve, and as now constructed the valve is said to fulfill in all respects the most rigid requirements. It is made of bronze composition, well finished, and has large springs, insuring great durability. It is simple in construction and warranted to be reliable, accurate and positive in operation. With full relieving capacity, it is very sensitive to excessive pressure, and admits of being finely adjusted.

The valves are provided with lock-key attachment, to guard against being tampered with, and adjustments of pop lid and pressure can be made from the outside of the valve, without taking it apart. The springs rest between ball and socket plates, which equally divides the pressure on the disc and are



THE LUNKENHEIMER POP SAFETY VALVE.

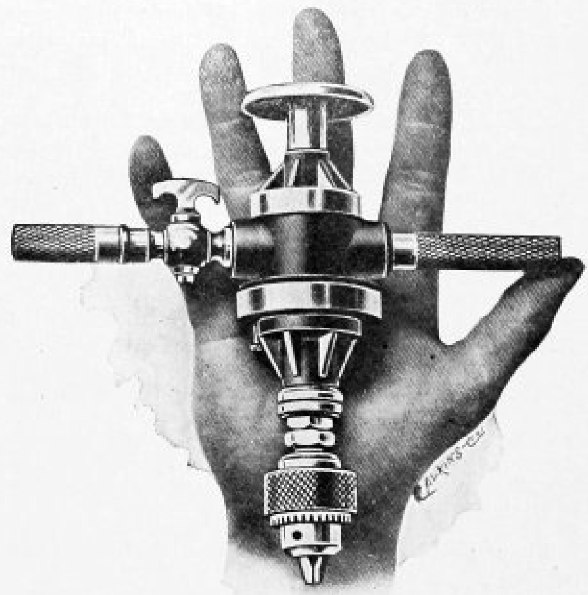
encased, hence the valve cannot be affected by back pressure. They have bevel seats, at an angle of 45 degrees to the vertical axis of the valve; are provided with suitable levers, by means of which the discs can be raised from their seats, and are allowed 1 square inch of valve area to every 3 square feet of grate surface of boilers.

To take the valve apart, the lever *U* is removed, then the bonnet *C*, after which the load on the spring is relieved by unscrewing the regulating screw *L*. The regulating ring screw *I* is then removed, and the bell *A* unscrewed. To set the valve for a higher pressure, it is only necessary to turn the regulating screw *L* down, and for a lower pressure, turn it up.

The pop or action of the escaping steam is regulated by the ring *H*, in the base of the valve, which is easily accessible without taking the valve apart, and is held securely in place when set by the regulating ring screw *I* on the side of the bell. If the valve pops suddenly and does not relieve the pressure enough, the ring *H* is turned up, which covers the drill holes and causes the disc to remain longer off its seat. If the valve pops too much, opening and closing gradually, then the ring *H* is turned down. When the desired adjustments is obtained the ring is secured by means of the screw *I*.

The "Chicago Midget" Rotary Drill.

A unique and novel rotary air drill, capable of drilling up to and including 3/16 inch in steel, is herewith illustrated. The machine weighs only 2½ pounds, and has a motor speed of 22,000 revolutions per minute with a spindle speed of 2,000 revolutions per minute. The distance from the top of the breast plate to the end of the spindle is 7⅝ inches. The dis-



MIDGET ROTARY DRILL.

tance from the center of the spindle to the outside of the housing is only 1 inch.

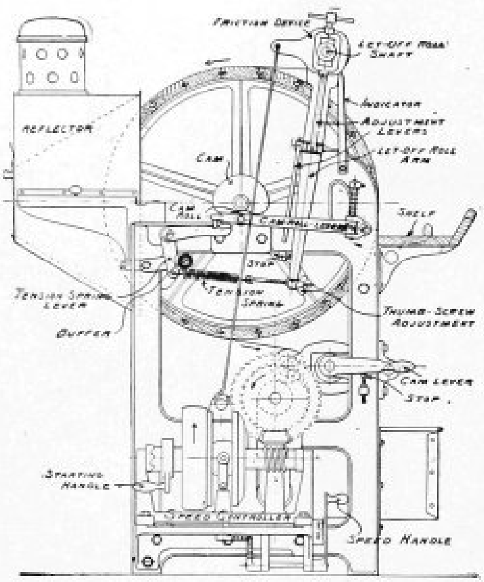
As this machine is of the rotary type it operates at full speed practically without vibration. It is particularly adapted to drilling tell-tale holes in stay-bolts and other general light work where acuracy is required. This machine has been produced and is being marketed by the Chicago Pneumatic Tool Company, Fisher building, Chicago, Ill.

The Federal Blue Printing Machine.

Of late years there has been created, in offices where blue prints are required in large quantities, a demand for some means of rapid printing by artificial light. To meet this demand a number of machines have been placed upon the market.

Of these, one of the most successful is the Federal blue printing machine, which has many points of superiority and has given universally excellent satisfaction. It combines economy, quickness, convenience and durability, is practically automatic, and is so simple that it can be operated by a boy. It makes continuous prints by electric light nearly as fast as they can be made by the most favorable sunlight. There is no loss of time in preparing the apparatus for each separate exposure, and in removing the work after the copies are printed. There is no glass to break from uneven pressure, heat, sudden change in temperature or careless handling, none being used in the machine. There is for practical purposes no limit to the length of a print which may be exposed, and this fact will be found of advantage in the printing of very long railway profiles or ship's lines, which are otherwise printed in sections and pasted together. Finally, the use of this machine obviates the hard labor required in handling the larger and more cumbersome apparatus.

The machine comprises a large drum mounted in roller bearings; an apron for effecting smooth contact between the drawing and the blue print paper; a reflector containing the electric lamps; a small electric motor; a speed-controlling device and a device for regulating the tension upon the apron. The action is simple. Upon a small roll above the drum is wound a long strip of flexible transparent material, called the "apron." This passes around the drum, being in contact with it for about half the circumference, and then passes between two rubber-pulling or drawing rolls placed underneath the drum. Perfect contact between the tracing and blue print paper is thus secured over the entire width of the drum. The speed of travel of the machine can be regulated to suit various trac-



SIDE ELEVATION.
FEDERAL ELECTRIC BLUE PRINTING MACH.

ings by means of a patent speed controller, the change being made while the machine is running, by simply moving a lever to different notches on a sector.

A small motor of ¼ H. P. is used, or a belt may be connected from an overhead shaft to the speed controller, if the machine is placed in a room provided with power. The motor and lamps are supplied for either direct or alternating current. The machine is made in three sizes, to print up to 30, 42 and 54 inches wide, and having, respectively, four, six and eight lamps each. The height of the machine from floor to the top of the lamps is 4 feet 10 inches, its depth is 4 feet 6 inches, the width of the three sizes being, respectively, 4, 6 and 7 feet. The machine is manufactured and placed on the market by Keuffel & Esser Company, 127 Fulton Street, New York.

PERSONAL

MR. WILLIAM H. DANGEL, formerly secretary of Scully Steel & Iron Company, has recently opened offices at No. 140 Dearborn street, Chicago, and under the firm name of W. H. Dangel & Co., will conduct a general supply business for boiler makers, railroads and iron workers generally. As manufacturers' agents and dealers they will sell a full line of tools, supplies and machinery.

SELECTED BOILER PATENTS.

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

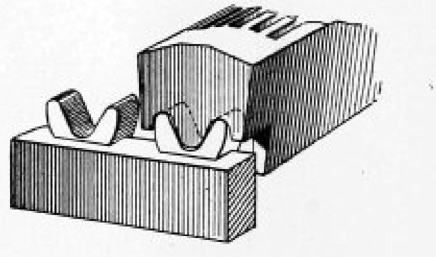
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

834,058. BOILER FURNACE. Percy Jackson, Macon, assignor to J. S. Schofield's Sons Company, Macon, Ga.

Claim.—A boiler furnace provided with a heat generator, comprising a cylindrical envelope closed at the front end and open at the rear end, the envelope having a lining of a non-heat-penetrating material, a fire-box in the front end of the envelope, a bridge wall built within the said envelope, and an air duct extending in through the rear end of the envelope to the said bridge wall to connect with openings therein leading to the ash-pit of the fire-box, the said air duct having its roof arched and its ends abutting on the said lining. Five claims.

835,024. GRATE. Augustus C. Hepp, New York, N. Y.

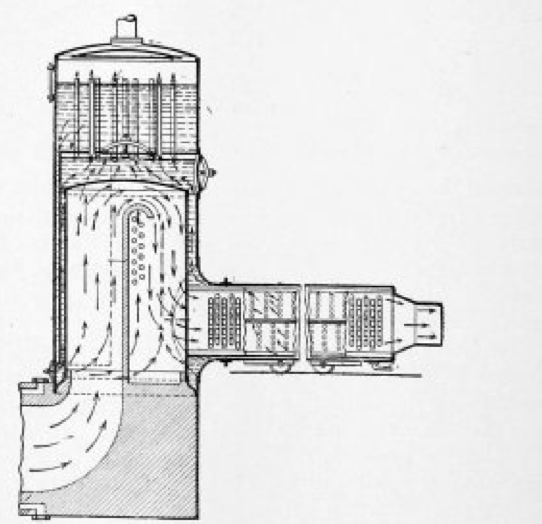
Claim.—A grate bar having spaced upward projections and an intermediate downward depression, in combination with a grate section having spaced upward depressions and an intermediate downward projection, the projections of the grate bar being adapted to enter the depressions of the grate section and



the projection of the grate section adapted to enter the depression of the grate bar, the adjacent side walls of the grate section projection and grate bar depression being inclined relative to each other and the lower end of said grate section projection being of slightly greater dimensions than the bottom of the grate bar depression, and the upper ends of the grate bar projections being of smaller dimensions than the grate section depressions, whereby the grate section contacts with the grate bar only at the top of the grate-bar projections and at single points on the side walls of the grate bar depression above the bottom thereof. Two claims.

835,872. STEAM BOILER. Paul Ssiway, of Kochma, Russia.

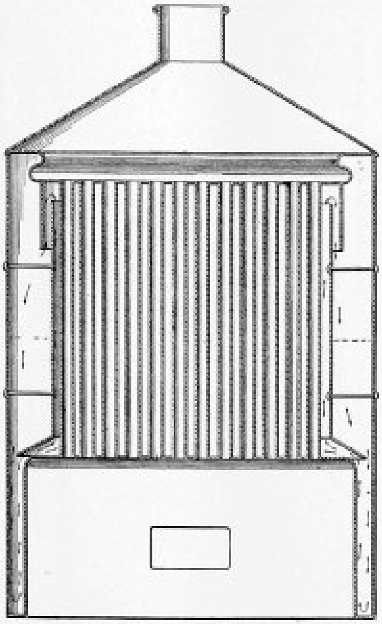
Claim.—An upright boiler with fire-box wherein a hori-



zontal feed-water heater with fire-tube for the discharge of the gases opens directly into the water space of the boiler, the feed-water heater being made of sufficient length for effectually utilizing the heat of the combustion gases. One claim.

835,749. STEAM BOILER. Miles Connor, Pueblo, Col.

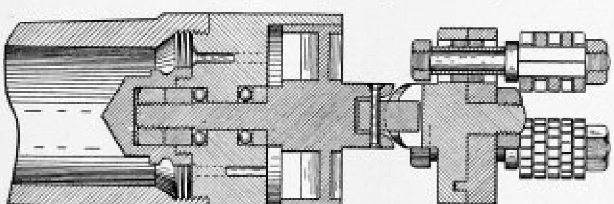
Claim.—In a boiler of the class described, the combination with an outer casing; of a fire-box surrounded by said outer



casing, a crown sheet over said fire-box, the wall of the fire-box at its juncture with the crown sheet being substantially S-shaped to form corrugations, a tube sheet at the upper end of said casing, said tube sheet being disposed in two planes and the metal disposed between the two planes of the tube sheet being substantially S-shaped to form corrugations and tubes connecting said crown sheet and tube sheet. Two claims.

836,267. BOILER-TUBE CLEANER. Eugene Mettler, Indianapolis, Ind., assignor to Lagonda Manufacturing Company, Springfield, a corporation of Ohio.

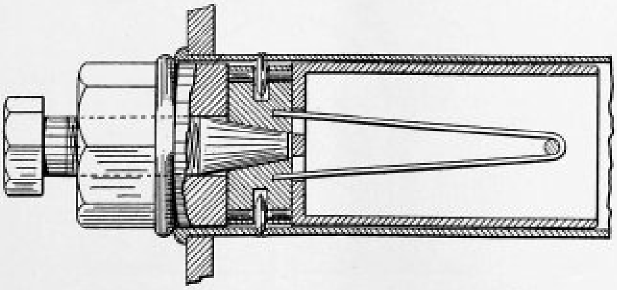
Claim.—In a tube cleaner, a rotatable head having radial slots, each slot having opposed guiding surfaces, an arm ar-



ranged in each slot with trunnions bearing on said guiding surfaces, upon which trunnions said arm is pivoted, and cutters carried by each arm, said head being divided into two separable parts in a plane transverse to its axis of rotation and lying between the guiding surfaces. Four claims.

837,426. BOILER-TUBE CUTTER. George Frederick Seymour, of Hollister, Cal.

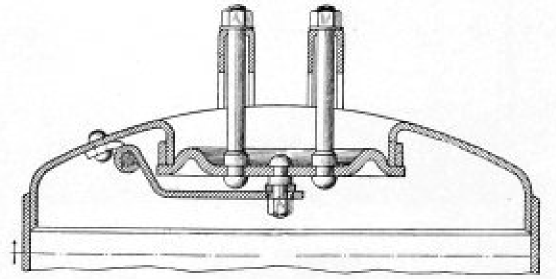
Claim.—A tube-cutter comprising a rotatable head, of later-



ally-movable cutting means actuated thereby, a hollow body portion carried by said head, and constituting at one end a guide for the cutting means, resilient means within said hollow body portion for normally holding the cutting means inward, and means for forcing the cutting means against the inner surface of the tube to be cut. Three claims.

836,859. MANHOLE PLATE OR COVER. John Rowland Brown and Isaac Harter, Jr., of Mansfield, Ohio, assignors to the Stirling Consolidated Boiler Company, of New York, N. Y., a corporation of New Jersey.

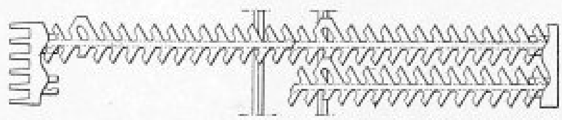
Abs.—The invention is designed to provide a manhole plate or cover which is capable of adjustment in a vertical and hori-



zontal direction and also for rotation around its center, these adjustments being necessary to provide for correct centering of the plate after the position of the manhole-lug has been determined. Eight claims.

837,543. FIRE-GRATE. Horace Budd, of Philadelphia, Pa.

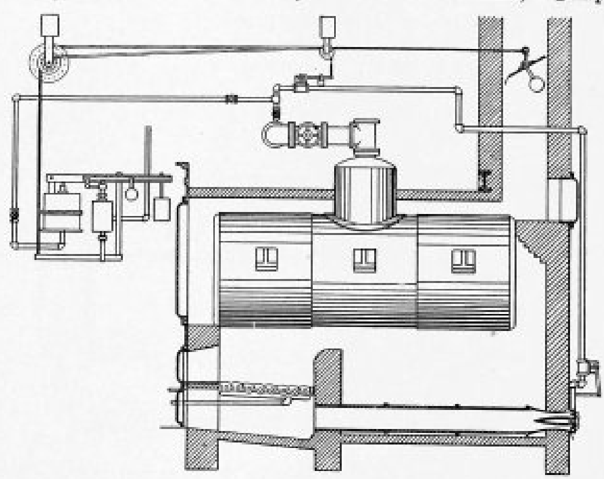
Claim.—In a fire-grate, an end member having a plurality of vertically-arranged openings therein, one side wall of each opening being provided with a vertical groove, and a plurality



of grate-bars, each being provided with a vertical rib and having one of its ends arranged within one of said openings, and its rib arranged within the adjacent groove, whereby said bars are maintained in vertical positions and in spaced relation to each other and whereby endwise motion of the bars from within said openings is prevented. Four claims.

837,609. BALANCED DRAFT APPARATUS FOR FURNACES. Charles T. Coe, of Kearney, N. J.

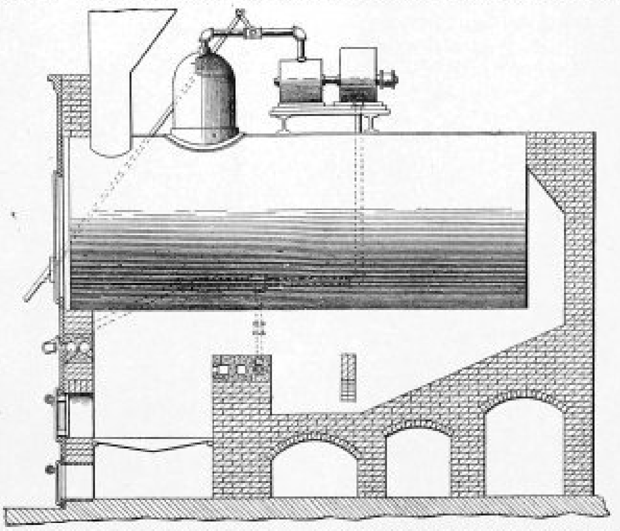
Claim.—In a balanced draft apparatus the combination of a boiler, a furnace for the boiler, a flue for the furnace, a damper



in said flue, a blower connected with the furnace, a regulator connected with the boiler, a valve for the blower, a pulley with steps of different diameters journaled between the regulator and said damper and said valve, a connection between the regulator and one of the steps of the pulley, a connection between another step of the pulley and the damper, a connection between a third step of the pulley and the said valve to enable the said blower and said valve to be operated simultaneously. Four claims.

838,364. FURNACE FOR STEAM GENERATING BOILERS. Isaac M. Sullivan, of Springfield, Ohio, assignor to the National Smoke Consumer Company, of Dayton, a corporation of Ohio.

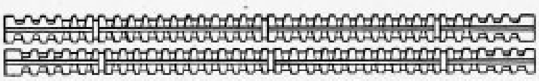
Claim.—In a boiler furnace, the combination, with a fire-box and grate-bars, of a bridge-wall and a front wall, an air nozzle supported on the upper edge of said bridge wall and provided with a tortuous passage having discharge outlets substantially parallel with said grate-bars, an air nozzle supported on the



front wall and provided with a tortuous passage having discharge outlets inclined toward said grate-bars, whereby the air currents from said nozzles intersect at an acute angle, and an air-blast apparatus connected to the outer end of said tortuous passage. One claim.

838,431. FURNACE GRATE. Thomas E. Martin, of Buffalo, N. Y.

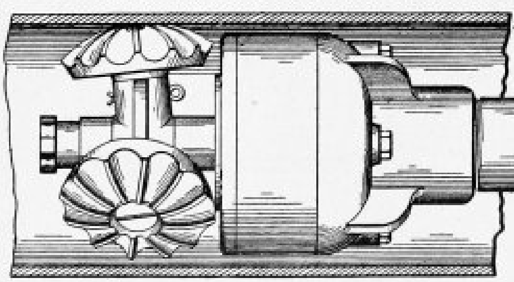
Claim.—A grate comprising in combination bearing-bars, and a plurality of grate-bars supported in the bearings of said bearing bars, said grate-bars adapted to be reversed end for



end in said bearings and provided with teeth extending laterally from the sides thereof, said teeth being so arranged that when each bar is reversed those on one side of the bar will occupy the positions which were occupied by the spaces on the opposite sides before reversal. Eight claims.

838,088. ROTARY MOTOR OR TURBINE. Cyrus S. Dean, of Buffalo, N. Y., assignor to Albert D. Jamieson, of Buffalo.

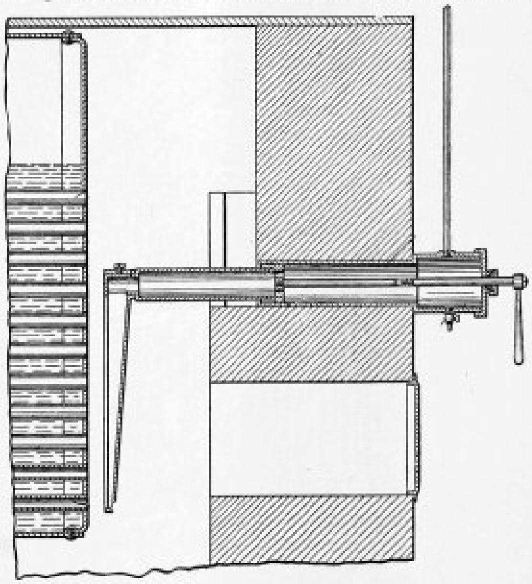
Abs.—This invention relates to rotary motors for operating tube or flue cleaners or scrapers. Its vanes are arranged trans-



versely of the wheel at right angles thereto, and the ducts or ports conveying the motive fluid discharge in the same plane as that of the turbine-wheel, whereby the turbine-wheel is subjected to rotary action only and all end or side thrust is entirely obviated. Three claims.

838,898. BOILER CLEANER. Charles H. Prescott, of East Liverpool, Ohio, assignor of one-half to S. S. McCurdy, of Toronto, Ohio.

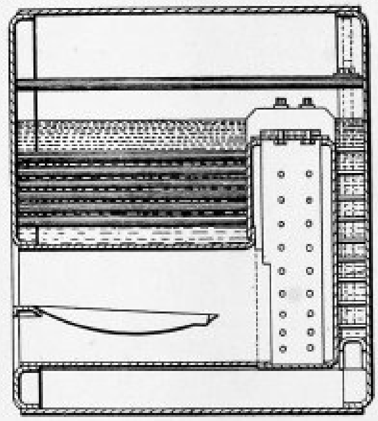
Claim.—In combination, a boiler having flues and a wall opposite the same having a chamber provided with an opening on the inner side of said wall, a boiler cleaner comprising a rigid tube passing through said wall, a second tube slidably and rotatably mounted within said first tube and having a rod projecting from said first tube, said rod being adapted to be manually operated to move said second tube within said first tube, and a nozzle mounted at the end of said second tube and at an angle therewith, said nozzle tapering toward its free end and having a longitudinal slot, said nozzle further being adapted to be withdrawn into said chamber in an in-



operative position. Six claims.

839,166. STEAM BOILER. Nicol MacNicoll, of Glasgow, Scotland.

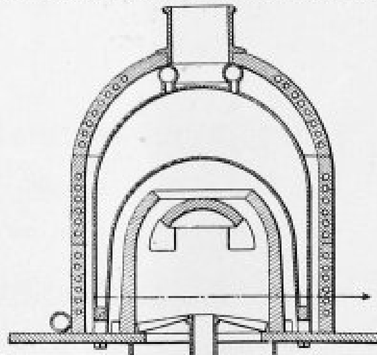
Claim.—In combination with a steam boiler, means for separating a shell into two compartments for forming a steam



chamber below the contained water, and means forming a communicating conduit between said steam chamber and the space above water level, said steam chamber extending at the bottom of said shell beneath the boiler furnace. Three claims.

839,808. SUPERHEATING BOILER. Franz Burger and Henry M. Williams, of Fort Wayne, Ind.; said Burger assignor of one-half of his right to said Williams.

Claim.—The combination with a dome-shaped boiler having



an internal fire-box, of a superheater embracing the boiler and providing a passage for the products of combustion from the fire-box between the outside of the boiler and the inside of the superheater. Six claims.

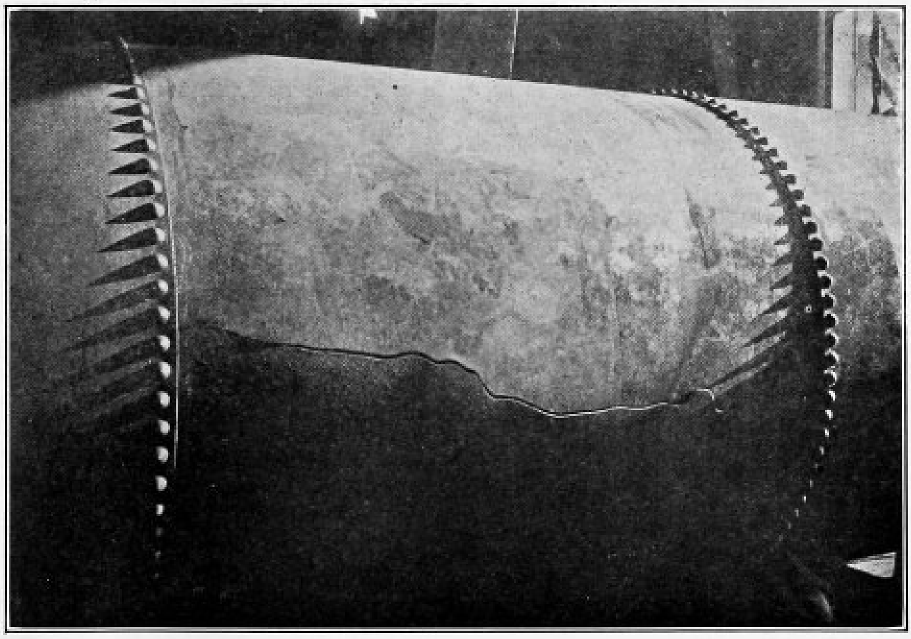
THE BOILER MAKER

VOL. VII APRIL, 1907 No. 4

AN ODD BOILER FRACTURE.

BY J. M. JONES.

I wish to contribute an account of a peculiar rupture of a boiler while being tested by a water pressure, just after repairs on the boiler had been completed. The boiler was of horizontal tubular type, 72 inches diameter by 18½ feet long, containing 92 tubes 3½ inches diameter by 17 feet long. The shell was made of Central fire-box steel 7-16 inch thick, three courses, one plate to a course. The heads were of flange steel properly braced. The girth seams were butt joints with double covering straps, triple riveted. The tensile strength stamped on the plates was 55,000 pounds. The boiler was made by a manufacturer of excellent reputation. It had been in use about eight years.



PHOTOGRAPH OF THE FRACTURED SHEET.

At the regular internal inspection, it had shown no oily deposit. Some six months after the last inspection by the insurance inspectors, a special inspection was called for. The inspector found that the first plate on the bottom, just forward of the girth seam, was bulged about 1¾ inches at the deepest part, and the plate was more or less affected to an extent of about 3 feet square. The girth seam and the front of the second course were forced slightly upward. The front head below the tubes was drawn backward about ⅜ inch out of line, and the lower row of tubes projected about 3-16 inch farther forward from the head than before the bulging occurred. The cause of the bulging was a deposit of cylinder oil, no oil separator being used.

The writer was called on to advise as to repairs. As repairs could not be made with the boiler in place, it was taken out and carted to a boiler shop. In making repairs, it was necessary that the strength be kept to maintain a working pressure of 120 pounds per square inch. Previous to the bulging, the safety valve had been set at 128 pounds, and after the bulging the boiler had been in use for some time at pressures varying from 110 to 120 pounds per square inch. The repairs consisted of a new plate, making about two-thirds of the first course, with a triple-riveted butt-strap joint at each end. While repairs were being made, they were viewed a number of times by the inspector, and all found properly done. The rivet holes in the new plate were punched ¼ inch small, and reamed out in place to full size, 15-16 inch diameter. No upward tendency of the second course at the girth seam was noticed.

While being prepared for a pressure test of 180 pounds, the second course on the bottom fractured nearly across to the second girth seam at a pressure of 113 pounds, as shown by the photograph. The repairs cost about $500. After the test and fracture, the boiler was sold for $80.

Steel Castings for Boiler Fittings.

After investigations, made under the direction of the executive committee, composed of the supervising inspector-general and the supervising inspectors of the Second and Third Districts, I have the honor to report as follows:

There are several companies that have agreed to make steel castings for use in connection with marine boilers and their steam and feed pipes, guaranteeing that the said castings shall have the following physical and chemical characteristics:

Tensile strength	minimum	60,000 pounds.
Elastic limit	minimum	30,000 pounds.
Elongation, 2" between marks	minimum	25. percent.
Phosphorus	maximum	.045 percent.
Sulphur	maximum	.035 percent.
Silicon	maximum	.50 percent.
Carbon	maximum	.40 percent.
Carbon	minimum	.20 percent.

These companies have filed duplicate letters guaranteeing these qualities, and designating the marks they will place on such guaranteed castings to identify them as being so guaranteed. One copy of each of these guarantees is filed with the supervising inspector-general and the other with the supervising inspector of the district in which the foundry is located.

At the last meeting of the executive committee the immediate revision of Section 20, Rule II., was urged by Mr. Lovekin, of the New York Shipbuilding Company, but the committee decided that it was best to have the matter considered by the board as a whole, and in the meantime to obtain additional information bearing on the subject. For this purpose the supervising inspector of the Second District has visited ten steel foundries and consulted many well-informed boiler makers and other men.

The object of the reduction of the tensile strength minimum from 62,000 pounds to 60,000 pounds in steel castings is to ensure that the physical tests will be less severe than the chemical requirements, and that if the test of a heat shows that it has the chemical requirements the maker will know the product will stand the physical test. The steamboat inspection service has the means of pulling coupons but not of making chemical analyses. With the changed specifications, if a coupon cut from any steel casting should fail to meet the physical requirements, we may be sure that an analysis would demonstrate a deficiency in the chemical requirements. The elastic limit and elongation requirements have not been changed. Reduction of area is not now specified, for ductility seems fully as well shown by elongation as by reduction of area. Reduction of area is much harder to measure than elongation, and we see no advantage in the retention of both requirements.

The maximum of phosphorus and sulphur allowed have been raised from .04 and .03 to .045 and .035. To retain these at .04 and .03 would greatly reduce the number of competing makers of steel castings. One foundry company is making a great success, and turns out castings so perfect, that so far less than 1 percent of their output has been returned because of defects. This success is largely due to the use of very large risers and often making several risers on one casting; but it is partially due to the low phosphorus and sulphur in their product. When their works were visited the president showed their test cards, which ran very uniformly, .042 phosphorus and .031 sulphur. Now, however, they decline to guarantee .045 and .035 because of the difficulty in obtaining American pig low enough in phosphorus and sulphur to give these results, and suggest that we raise the limit of both to .05. Some makers wish the board to do away with the chemical requirements altogether. Others believe we should raise both the phosphorus and sulphur limit to .05, which is the Navy requirement.

Among the works visited by the supervising inspector of the Second District was one company whose product generally consists of heavier castings, such as side frames of locomotives. The risers are broken off instead of sawed, and the fractures show great solidity. This firm also declines to make at present marine castings up to the specifications suggested herein, because of the difficulty in getting the phosphorus and sulphur as low as required. But the supervising inspector of the Third District has shown the committee physical tests of eight castings made last October for the Maryland Steel Company, which averaged 65,900 pounds tensile strength, 33,750 pounds elastic limit, and 29 1/10 percent elongation. Undoubtedly, castings possessing such physical characteristics would exceed the chemical requirements.

It is dffiicult to get at present suitable pig, and one firm who agrees to the specifications uses English pig iron entirely. Perhaps the supply of Bessemer ore may soon exceed the demand, and in the Adirondack region they now claim that by washing out the granite crystals they remove a large percentage of phosphorus. Sulphur can be largely removed, we understand, by roasting the ore. Since the Navy specifications of .05 for phosphorus and sulphur each were made, great advances have been made in the art of steel casting, and some advance has been made within the last thirty days, and it would seem that our specifications should be made to at least require the best that can be produced to-day. If in the Second District there are already seven competitors who will guarantee castings having sulphur and phosphorus not exceeding .035 and .045, and the purchaser can have a choice between open-hearth, Tropenas and crucible steel, probably there are fifteen or twenty makers in the country, and there is no necessity of raising the limits.

In the judgment of your committee there is a necessity of guarding against excessive silicon. Almost all the malleable iron castings show excessive silicon and silicon unevenly distributed. Steel castings doctored by the admixture of ferro-silicon in the ladle show this unfused silicon segregated. In the converter process the silicon forms the first fuel, and until it has been consumed the carbon does not unite with the oxygen, so there is no silicon in the product except what is restored by the ferro-manganese or ferro-silicon. In the open-hearth process probably the silicon is not quite so thoroughly eliminated, but no open-hearth maker has so far objected to the limit of .50 for silicon, and .30 is the common percentage.

Probably some will ask why require a maximum and minimum limit of carbon, and will say that you cannot have 60,000 pounds tensile strength with .20 or less carbon, but of late steel has been made of very low carbon but of high tensile strength, owing to excessive manganese. Unless it were to give high tensile strength to low carbon metal, there is no object in using too much manganese, as ferro-manganese is now worth about 4 cents a pound.

As an example of what can de done in making good castings we file with the supervising inspector general a test report of two separator heads for the steamers *Yale* and *Harvard*, made for the W. & A. Fletcher Company. These show, respectively, 70,500 pounds and 70,000 pounds tensile strength, 38,500 pounds and 37,000 pounds elastic limit, 27 and 29 percent elongation, phosphorus .032, sulphur .026, silicon .30, carbon .30, and manganese .52. They bent to an angle of 180 degrees, and when broken showed silky fracture.

It would appear wise, at least for the present, to only approve steel castings for use in connection with a marine boiler, when they are made by one of the three standard processes already mentioned. A sample of steel is presented herewith and probably no finer cast metal can be produced, but we consider this metal unreliable, believing it is produced by a

* Abstract of a paper read by Captain Ira Harris, of New York, at the annual meeting of the Board of Supervising Inspectors, Steamboat Inspection Service.

mechanical mixture instead of by chemical combination. Nine times out of ten, and perhaps 99 out of 100, it is splendid and is sold new, we understand, for about 4 cents a pound more than open-hearth castings, but the one hundredth time it will be a complete failure, and therefore the Government will not admit its use in gun making. It is the same way with all metal made originally of steel scrap melted with cast iron in different proportions and generally called semi-steel. The result is too uncertain. We should have a reliable, uniform metal.

It may be explained why the converter processes mentioned above are spoken of sometimes as Tropenas and sometimes as side blowing. The Tropenas process has tuyeres at two heights, while side blowing converters have only one row of tuyeres and fill the converters right up to that row. Several makers who have Tropenas converters use only the lower row of tuyeres, and in that case do not differ from the side blowing practice.

A few words about valves, as distinct from other fittings on boilers and steam pipes. So far as we know no good steel valve has been produced by casting by the open-hearth process. Probably the failure sometimes has been caused by a belief that as steel was twice as strong as cast iron the valve body need be only half as thick. The valves were then not stiff enough and would spring. Valve patterns are generally complicated, and the metal poured from an open-hearth furnace may be too stiff to flow in the mould and cool homogeneously. It is naturally prone to blow holes and shrinkage cracks. Metal melted in Tropenas converters is more fluid, and it may be that good valves can and will be cast by this process. One company is experimenting with valves cast of converter metal, and we present a piece of fin cut from a fresh casting. This fin can be bent 180 degrees a number of times without breaking, and the rough valve shows no defects. We also present a piece of the spine and of the fin from a very difficult casting made for an ammonia machine to stand 500 pounds pressure. It is suggested that these be compared with one another. Recently as an experiment a check and stop valve combined was cast for the W. & A. Fletcher Company. This was the first attempt, and was purely an experiment. The casting cleaned (but not machined) was examined and no defects were discovered. By leaving the crucible in the fire longer the melted metal can be poured when in a highly fluid state, and we see no reason why valve bodies cannot be cast in this way just as easily as by making them of semi-steel or ferro-steel.

There are now on the market valves made of ferro-steel and of semi-steel which are greatly superior on an average to those of cast iron, but the resulting metal is dependent on the mixture, and the exact nature of the material cannot be known as definitely as steel.

It is so much easier to make a good, solid casting of iron, and foundry men have so much more experience with cast iron than with cast steel, that it is questionable whether in making large valves cast iron should be discontinued. So far as we know, large valves made of malleable iron have proven failures. The proposition of another member of the board, to have valves (at least large sizes) tested, is at least for the present probably the best way to ensure safety, but by the time the board again convenes steel foundries may have solved this problem satisfactorily.

The remaining question to consider, and one which we hope to have discussed, is the use of malleable iron, especially in large sizes. One member of the executive committee has expressed the opinion that no malleable iron fitting larger than 3-inch should be used around a marine boiler, and another member would limit their use to 4-inch or under. During the past six months, in four vessels of the Second District, malleable iron fittings on a certain type of water-tube boiler have given out. In each case there seems to be some mystery, and the steamboat inspectors and the officers of the boiler company have made great efforts to learn all that is possible to learn concerning the causes of the accidents. The department has authorized seven more chemical analyses, and it seems improper, in a paper like this, to discuss these accidents, except as to the metal in the parts that gave way.

We present herewith a small piece of the section of one manifold which burst, killing the engineer and four other men. The original fracture showed quartz particles so segregated as to make us sure that its analysis would show high silicon. A quantative analysis of this same section showed silicon 1.17 percent, sulphur .075 percent, phosphorus .20, and manganese .30. Either the high phosphorus or the high silicon should condemn such metal for use in or about a boiler. But it was not only the great percentage of silicon and phosphorus which made this metal dangerous but their unequal distribution, as shown by the physical tests of two coupons cut from the same broken section. One of these showed tensile strength of 28,070 pounds, and the other 23,736 pounds, or more than 15 percent less. The ductility was too small to be measured. While we have not finished investigating this matter yet, it is clear that such metal is out of place in boiler work.

In another case two nuts gave way, scalding two men. These nuts had long been in service, and it is not surprising that they gave out, but it is strange that they gave way under less than half the pressure to which they had been subjected a short time previously.

The third accident is still being investigated. The fourth accident was without injury to person, but is also mysterious. The bottom cross manifold of a water-tube boiler installed on a yacht cracked when under only 50 pounds pressure. When the vessel was inspected six days previously, it was subjected to 375 pounds pressure. This manifold was a bottom one, so that it was surely full of water, and it is hard to see how a water hammer could have caused it to give way. The boiler was built in 1899. It is, of course, not impossible that strains were put in the metal by the pressure applied at inspection, but malleable iron is not a metal that carries strains long without their being manifested.

In one of the fractured specimens it can be seen that the decarbonization has acted 1/16 inch deep inside and out, leaving 5/16 inch of cast iron. It is questionable whether it would not have been stronger to resist a burning strain if it had not been decarbonized. The malleable part being so much more ductile would not reinforce the cold short part, and the latter may have given way first, just as a cylinder banded with one tight and one loose band is no stronger than if banded with one tight one alone. We believe that this has something to do with the failure of malleable iron valves.

Perhaps two years ago this same company commenced to make manifolds of a metal much superior to the malleable iron which had been used previously. A coupon cut from one of these gave 52,300 pounds tensile strength and elongation 18.8 percent. The reduction of area was 20.8 percent. While this metal is called malleable iron it is not ordinary malleable iron. An examination of the fracture shows that it is not cast iron decarbonized by slow heat when in scale, but we see particles of silicon which clearly proves that after the metal was melted and the silicon burned out, ferro-silicon was added in the ladle. Probably this metal was melted in a reverberatory furnace, and the casting was subjected to subsequent heat treatment. We see no evidence of decarbonization, and consider that it might as well be called steel as malleable iron. We do not believe it safe to use "doctored" metal or any metal whose good qualities came from mechanical admixture instead of chemical combination when fused. No dependence can be placed on such metals.

In conclusion, we repeat that the art of steel casting is rapidly advancing. The high temperatures, due to the advance in steam pressures, prevent us from looking to composition for boiler and pipe fittings. Cast iron is good and reliable, but is too heavy if of necessary thickness to ensure safety at high pressures, and it would seem that steel was the metal we must use.

The Lay Out of a Four-Piece, 90-Degree Elbow with Large and Small Ends on Each Course.

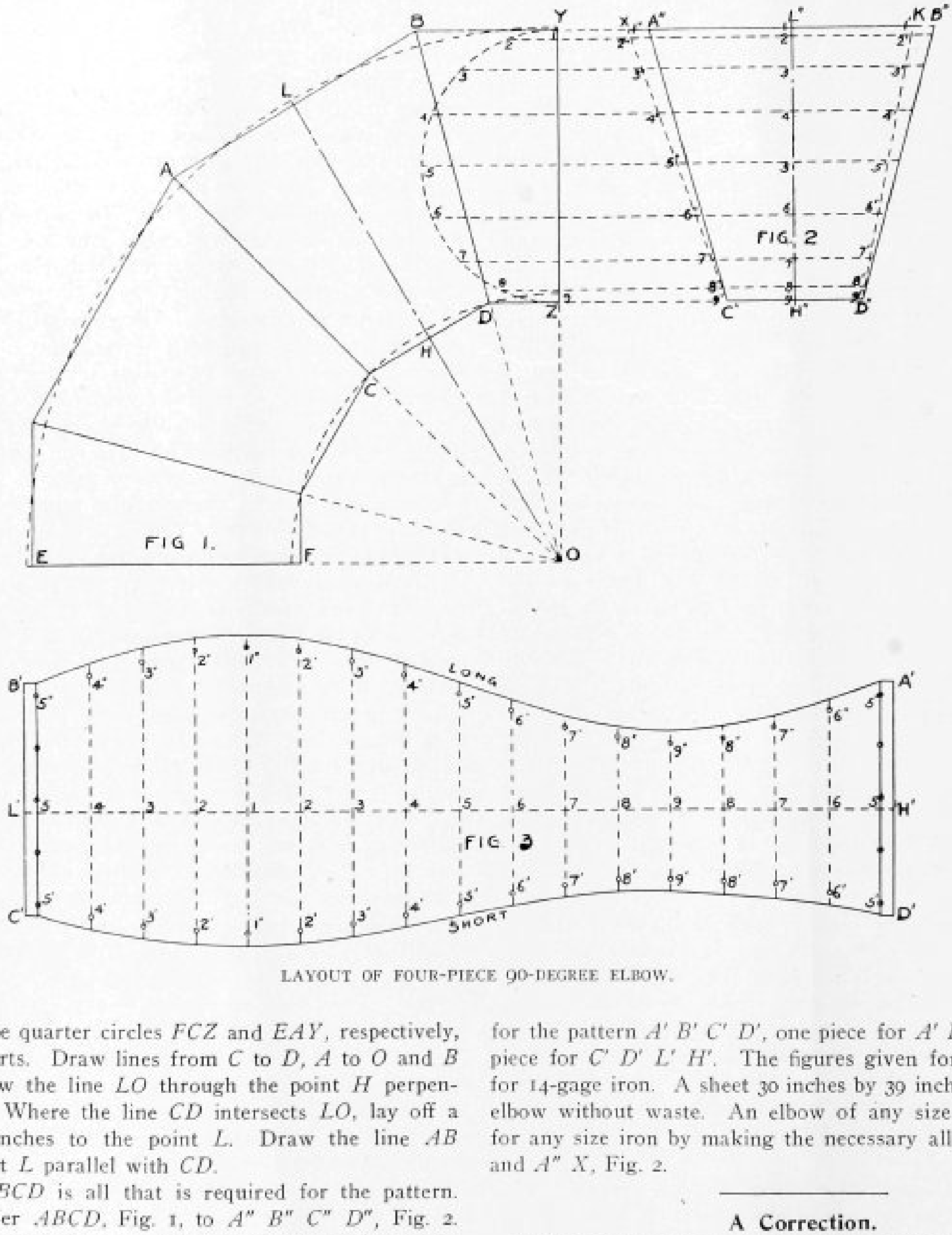
BY J. H. SHERIDAN.

Draw the lines *EO* and *YO*, Fig. 1; then with *O* as a center and with the trammels set to a length of 12 inches, draw the quarter circle *FCZ*. With the same center and with the trammels set to a length of 24 inches, draw the quarter circle *EAY*. Divide the quarter circles *FCZ* and *EAY*, respectively, into six equal parts. Draw lines from *C* to *D*, *A* to *O* and *B* to *O*. Also draw the line *LO* through the point *H* perpendicular to *CD*. Where the line *CD* intersects *LO*, lay off a distance of 12 inches to the point *L*. Draw the line *AB* through the point *L* parallel with *CD*.

The course *ABCD* is all that is required for the pattern. Therefore transfer *ABCD*, Fig. 1, to *A″ B″ C″ D″*, Fig. 2. Describe a semi-circle on the line *YZ* and divide it into eight equal parts. Draw horizontal lines from the points 1, 2, 3, 4, 5, 6, 7, 8 and 9, Fig. 1, extending them until they intersect the line *B″ D″*, Fig. 2. On the line *B″ A″* mark *K* 1 inch from *B*. Draw the line *KD″*, and then lay off from *A″* the distance *A″ X* equal to 1 inch. Draw the line *XC″*; then the measurements for the development, Fig. 3, should be taken from these lines *KD″* and *XC″*, Fig. 2.

Draw the line *L′ H′*, Fig. 3, 38 inches long, and divide it into sixteen equal parts. Draw lines through these points of division at right angles to *L′ H′*. Mark these lines with the same numbers as were used for the corresponding points, Figs. 1 and 2. Measure the distance from 1-1″, Fig. 2, and transfer it to 1-1″, Fig. 3. In a like manner transfer the distances 2-2″, 3-3″ 4-4″, etc., to Fig. 3. Having completed the pattern on one side of *L′ H′*, transfer the distances 1-1′, 2-2′ 3-3′, 4-4′, etc., Fig. 2, to the corresponding lines in Fig. 3. The points thus located are to be punched for rivets. Add the lap outside these points and the pattern is completed.

The development shows that the line *A′ B′*, Fig. 3, is longer than the line *C′ D′*, thus showing how the large and small ends are obtained. Two pieces of stock will, therefore, be needed for the pattern *A′ B′ C′ D′*, one piece for *A′ B′ L′ H′* and one piece for *C′ D′ L′ H′*. The figures given for this layout are for 14-gage iron. A sheet 30 inches by 39 inches will make the elbow without waste. An elbow of any size can be laid out for any size iron by making the necessary allowance at *B″ K* and *A″ X*, Fig. 2.



LAYOUT OF FOUR-PIECE 90-DEGREE ELBOW.

A Correction.

At the bottom of page 84 in the March issue of The Boiler Maker, the equation $L = \frac{\sqrt{R^2 - S^2}}{2}$ should read

$$L = 2\sqrt{R^2 - S^2}.$$

Superheated Steam.

BY JOSEPH H. HART, PH. D.

The use of superheated steam is an extension in modern engineering practice, which received its first impulse in Europe. The utilization of superheated steam has become a common practice there, and in this country it has only recently come to the front as a method of increasing the efficiency of the modern power producer. To-day, however, considerably over half a million horsepower are produced by this means and the quantity is steadily growing. While much knowledge has been obtained in this field from European practice, the tendency has been to go it alone, and the situation here to-day is somewhat chaotic and the methods of its production and utilization are varied. The utilization of superheated steam often requires changes in the construction of the boiler and the application of the heat at this point, and the best method of application is practically unknown. In order to understand the full connection of this development with present practice, we must necessarily briefly review the facts as they exist to-day in regard to superheated steam.

Superheated steam is steam which is heated in pipes after it has been produced in the boiler. The presence of water in the immediate vicinity in the boiler prevents its superheating. In order to understand this we must understand what is meant by superheating. Air is superheated gas. It is above the critical temperature and no amount of compression at this temperature can liquefy it. If it were constantly in contact with liquid air it would no longer remain superheated. The extra heat in the air would cause a portion of the liquid to evaporate, thus increasing the quantity of air in the vapor state, but lowering its temperature. Superheated steam, therefore, when in contact with water is in an unstable condition and rapidly tends, of its own accord, to approach equilibrium by this method. In practice the steam is drawn from the boiler through pipes which are then heated, the steam being sufficiently removed from the water to prevent its action occurring to any great extent.

Superheated steam is produced simply by making it traverse slowly pipes which are considerably hotter than it is and keeping it from contact with water at this temperature. Steam not in contact with water can be heated to any temperature. The prevention of contact is often accomplished by the use of automatic valves, but in some cases reliance is had simply upon length of steam path from boiler. The pipes are heated by gas burners, or by a bed of coals, or by the use of oil or gasoline burners. This heating of the steam is precisely analogous to the use of a reheater in the operation of compressed air. It increases the pressure and temperature of the steam without increasing its volume or diminishing the quantity at hand. The limit of the increase of temperature depends simply upon the temperature of the superheater and the length of time that the steam remains in it. Steam gas, which, in reality, steam becomes in this condition, is a fairly poor conductor of heat. Hence it must be heated for considerable periods of time to produce the rise in temperature. This is true, at least, in comparison to the time intervals required in the ordinary boiler.

Now, superheaters can best be installed with a minimum economy in the boiler itself. The most desirable point for a superheater in a boiler setting is where the products of combustion have given up a portion of their heat to the boiler surface, but before they have passed over the greatest amount of heating surface. The conditions governing the position of this installation depend almost entirely upon the kind of boiler in which it is installed, and upon the pressure at which the boiler operates. It must be borne in mind that the superheater must be very hot, and allowances must be made for this condition. The boiler itself is kept comparatively cool on account of the mass of water in contact with it and the constant absorption of heat, due to the latent heat of vaporization of the water. The efficiency of a superheater and its capacity depends simply upon its size and temperature. The majority of superheaters, in order to reduce the temperature as much as possible, have been increased in size proportionately. This is a necessary evil. The temperature often rises to such an extent, even under present conditions, that it may prove dangerous and the maintenance of the superheaters in efficient operation under these abnormal conditions is extremely difficult. Expansions and strains are much more pronounced than in the boiler itself. It must stand a much higher pressure, and the fire and the steam in this condition often produce chemical effects which are very deteriorating in their action. Thus, it is a matter of essential importance that the superheater be not put in the boiler at a place where it can get too hot. This is the chief cause of the burning out of this class of machines. Proper judgment used in placing it may result in a difference of 200 or 300 percent in the life of the device.

No attempt at present has been made to prevent undue heating of the superheater. Double pipes, enclosing between them a liquid of high boiling point, would undoubtedly increase the heat capacity of the machine and prolong its life. Such developments, however, are not apt to come for some time, as the temperature and pressure and general conditions under which superheaters are operated to-day are not those generally understood, and a complete knowledge on this point is necessary before further improvements can be produced. Sufficient to say, that superheat is in practical and efficient operation in a large number of plants to-day, that its best efficiency can be obtained in low efficiency plants, and in comparison to the other devices for increasing the efficiency, it possesses, probably, a minimum cost in comparison to the results.

A Disastrous Boiler Explosion at Sea.

On Feb. 13, 1907, the donkey boiler on the steamship *Valdivia*, of the Hamburg-American Steamship Company's Atlas line, exploded, killing seven of the crew, injuring four others and wrecking the smokestack and superstructure of the vessel amidships. At the time of the explosion the *Valdivia* was about a hundred miles south of Hatteras, bound for New York from Kingston. According to the statement of the chief engineer, the boiler, which, at its last inspection had been allowed a working pressure of 90 pounds, was in good condition, and 15 minutes before the explosion occurred was under a pressure of only 35 pounds per square inch, as indicated by the steam gage.

The boiler, which is shown in Fig. 2, was a Cochran vertical-cross tubular boiler, 11 4-12 feet in height, 63 inches diameter, built of steel by Clarke, Chapman, Parsons & Co., of Gateshead-on-Tyne, in the year 1886. It was located on the main deck of the vessel, forward of the smokestack of the main boilers. The dimensions in Fig. 2 are given in millimeters.

The shell of the boiler was made up of three courses, the middle course being the outside course as it lapped the upper and lower courses. The middle plate ruptured all the way across at a point about 2 inches from the lap of the longitudinal seam, then it tore around to the front tube-plate about 5/8 of the circumference, and just above the seam of rivets joining it to the bottom shell plate. The top shell plate tore off entirely around the boiler, directly above the seam of rivets joining it to the middle shell plate in a more ragged manner than the other plate; thus the upper shell plate and head were free from the power part of the boiler and were blown overboard, taking the safety valves, main and auxiliary stop valves, water gages, steam gage and gage cocks along. The heavy lines, Fig. 2, show the manner in which the plates were ruptured.

The plate forming the back of the combustion chamber collapsed, and laid against the back tube plate, about 13 inches further away from the shell than when in its original position. This plate was rolled to a radius of about 27 inches and was stayed with $1\frac{1}{8}$ inch diameter screw stays to the shell plates; stays pitched about $10\frac{1}{2}$ inches by 14 inches, except that in the second row from the top, one stay was left out in the middle as it came opposite a manhole in the shell. Some of the stays broke off at the back connection plate, but most of them pulled through the shell plate, into which they had been screwed and the ends riveted over; on the other end, the stays were screwed into the plate, and, in addition, had a nut on the end. The holes in the back connection plate around the stays were stretched to such an extent that the stays could be moved around by hand, and in several cases, the nut was all that prevented pulling them out of the plate.

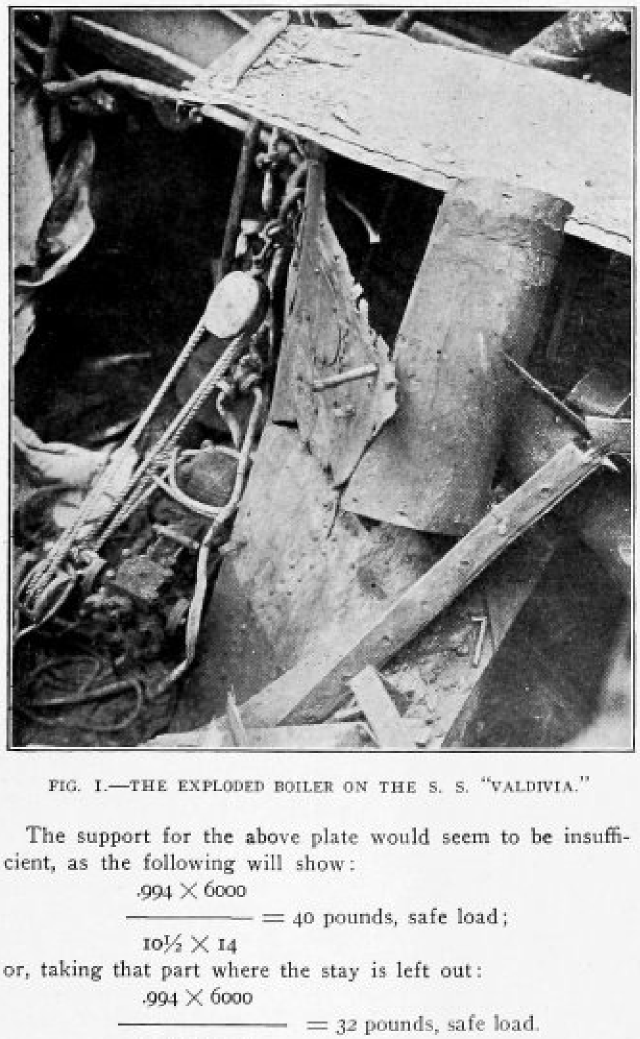


FIG. I.—THE EXPLODED BOILER ON THE S. S. "VALDIVIA."

The support for the above plate would seem to be insufficient, as the following will show:

$$\frac{.994 \times 6000}{10\frac{1}{2} \times 14} = 40 \text{ pounds, safe load;}$$

or, taking that part where the stay is left out:

$$\frac{.994 \times 6000}{147 + 36.75} = 32 \text{ pounds, safe load.}$$

Or, assuming that the *T. S.* of stay-bolt steel was 48,000, then $32 \times 8 = 256$ pounds, the ultimate strength of the stays. Of course, the circular form of the plate would assist in maintaining the plate in its position.

The plate forming the middle course was considerably reduced by pitting along the line of rupture across the plate, the pitting extending for a distance of from 10 to 20 inches in width. The following measurements were taken along the ruptured edge of the plate about 1 inch from the edge: .414 inch in thickness at the upper lap, which must have been the original thickness, as the plate did not show any signs of wasting away on the outside:

.363 inch in thickness, taken 7 inches down from upper edge.
.328 " " " " 14 " " " " "
.260 " " " " 21 " " " " "
.225 " " " " 28 " " " " "
.288 " " " " 45 " " " " "
.382 " " " " at bottom of plate.

No doubt the plate was reduced some where the measurements were taken by being drawn out.

Assuming the *T. S.* of plate to be 60,000 pounds, then

$$\frac{60{,}000 \times .225}{31.5} = 427 \text{ pounds, bursting pressure;}$$

or $427 \div 6 = 71$ pounds, safe load. An average of the seven measurements equals .323 inch.

$$\frac{60{,}000 \times .323}{31.5} = 615 \text{ pounds, bursting pressure;}$$

or $615 \div 6 = 102$ pounds, safe load.

The last inspection by the German Government inspectors was made on Oct. 15, 1904, when the donkey boiler was pressed to 11 1-3 atms. (160.86 pounds), found to be tight and in good condition, and allowed 6 1-3 atms. (90 pounds) steam pressure, as shown by abstract filed at the office of local inspectors, port of New York.

Mr. J. L. Crone, of New York, assistant inspector of boilers for the second district of the United States Steamboat Inspection Service, makes the following statement in his report regarding the cause of the explosion. "After making a thorough examination of the wrecked boiler, and from the general destruction of bulkheads, decks, above and below the boiler, and other parts of the vessel, I am of the opinion that the boiler had a pressure on it greater by several times than the 35 pounds reported; also, that the back connection plate collapsed first, and this shock, together with the ordinary strain exerted on it, due to the pressure, ruptured the shell."

An International Boiler Deal.

BY T. T. PARKER.

"Yes," said Mr. Murphy, as he blew the foam away, "I have been away, Hogan, attinding the funeral of me aunt at Budville. A good woman that, an' a big wake they had. Me cousin Delany and I had a time for three days, an' I come back money ahead by a biler deal. You see, Delany is a plumber an' does steam fittin' an' knows the town. So while samplin' the wet goods in a place, he introduces me to Schmitt, the brewer there. Well, we had a few bowls, between which, Delany tells Schmitt that what I dunno about bilers an' engines ain't on the map. An' the Dutchman, Hogan, gets excited an' tells us of the pirate in the town, who was tryin' to stick him up on a second-hand biler; an' Delany give me a kick on the sly. Well, Schmitt took us to the brewery; an' I am telling you, Hogan, we went wid a thirst to be proud of. Lyin' in the yard was the biler. I looked it over. There were fourteen fire cracks at the first girth seam an' two ring patches. There were sixteen bridges cracked between the tubes at the back head, an' the beads were off near all of them. Well, she was ready for the junk, an' the local pirate had dumped her on to Schmitt to carry 100 pounds, an' the Dutchman didn't know one end of a biler from a Jersey cow. Well, there was a county Clare man in the town be the name of Muldoon, an' he run a repair shop. Mind ye, he didn't build bilers, but bought city junk an' unloaded it on the peaceful an' unsuspectin' natives av the rural scenery. An' this Muldoon was in politics, bein' naturally a red-haired man, addicted to scrappin' be nature an' trained by trade. He worked two men an', Hogan, he owned the town. Delany was on the school board an' he toldt me av the biler there, on which they was afraid if they got 5 pounds she would explode, an' if they got below the air pressure she would collapse. So they piked it along, keepin' the valves open to the air all the time, an' wid all that, Muldoon runs in repairs enough to buy a new biler every year. Whin, Hogan, I fully got on to the scandalous facts of this layout, I pulled Delany to one side an' toldt him if ever they run that biler at the brewery there'd be no beer in town 'till the new one would be made.

"Now, Schmidt was afraid of the biler an' more afraid of Muldoon, an' he took me to the taproom an' said there would be one hundred bones due me if I got the biler off his hands widout Muldoon blamin' him. So I went an' wired for that says Muldoon, 'don't ye know me? I am the bilermaker that sold the biler.' 'Ye did not,' says Callahan, 'for I'll not let sich a second-hand junk pile run, not for you nor anny one else.' 'Man,' says Muldoon, 'ye don't know what ye are talkin' about. I am at the trade twinty years,' says he. 'An' larned nothin' yit,' says Callahan.

"An' so they had it out, wid Callahan havin' all the argicment an' pintin' out the wide assortment of defects that the biler died possessed of. In the end they went to the mat, but Muldoon lost out, owin' to the hammer catchin' him fair in the nose. After he got cleaned up a bit he asked Schmitt if he was goin' to back down from his bargain, an' Schmitt,

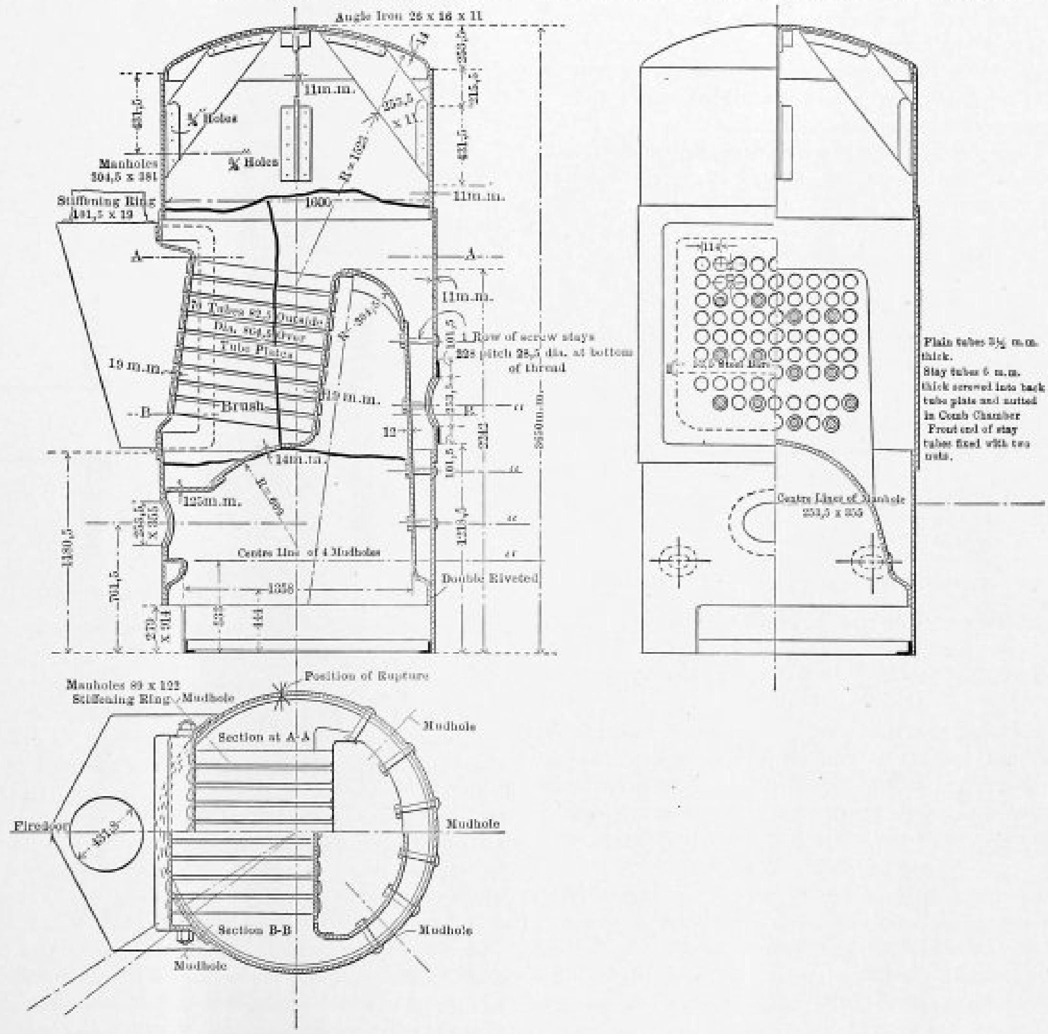


FIG. 2.—DETAILS OF THE DONKEY BOILER ON THE S. S. "VALDIVIA," SHOWING THE LINE OF FRACTURE.

old rat ov an inspector, Callahan, to come out at once, an' the next day he was at the hotel to meet me. I took him to the brewery, an' Schmitt took out insurance on the three bilers, an' thin Callahan wint for that second-hand scrap pile av a biler, while Schmitt telephoned for Muldoon. I wish, Hogan, ye could see that divil, Callahan, professionally examine a biler an' one like that. "Twas like a doctor examinin' the remains ov a dago after the dynimite. 'Tis a beautiful sight to see a man at work that has his trade at the inds, so as to speak, av his fingers. By the time Muldoon come, Callahan was writin' out the funeral notice av the biler and stampin' a big 'C' in the front head. Schmitt introduces us all, frindly like, an' Muldoon says, "Tis a fine biler, me boy,' to Callahan. An' Callahan, knowin' nothin' av the deal, an', carin' less, says, 'That ain't a biler; that's scrap,' says he. 'What,' bein, coached, toldt him he could not buy the biler unless the inspector would accept it for insurance; an' with that Callahan toldt Muldoon to take it an' save it for his tombstone.

"Well, we pulled thim apart an' Muldoon departed, nose an' all. Then Schmitt opened up a Dutch lunch in the taproom, Hogan. Man, man, but thim Germans know what to eat; an' wid the drink they have us beat a mile. Delany, and Callahan an' I wint out and wrote up all the bilers in the town—to the everlastin' ruination av that divil Muldoon. An' I comes back, after a royal time, wid money to burn. Such, Hogan, is the reward av a dacint man, showin' Hevin smiles on one an' puts a nose on the pirate."

"An'," says Hogan, "ye wint to one wake an' took in two."

"I did that," says Murphy, "and saved Schmitt's life at the same time."—*Power.*

How to Lay Out a Tubular Boiler.]

PART IV.

Having figured out the shell sheets and heads we will make up the bill of material as follows:

Material required for one 60-inch by 14-foot tubular boiler with butt joints:

One sheet, 7/16 inch by 83½ inches by 190¼ inches, for large course.

One sheet, 7/16 inch by 83½ inches by 187⅝ inches, for small course.

One sheet, ½ inch by 66⅜ inches diameter, for large head.

One sheet, ½ inch by 65½ inches diameter, small head.

In recent years steel has supplanted iron in boiler construction. Its use has become universal, because it can be manufactured more cheaply than iron, and thinner sheets may be used, since its tensile strength exceeds that of iron. It is as ductile and more homogenous than iron.

The following standard specifications for open-hearth plates were adopted by the Association American Steel Manufacturers:

Special Open-Hearth Plate and Rivet Steel.

Steel shall be of three grades: extra soft, fire-box and flange or boiler.

Extra Soft Steel.

Ultimate strength, 45,000 to 55,000 pounds per square inch; elastic limit, not less than one-half the ultimate strength;

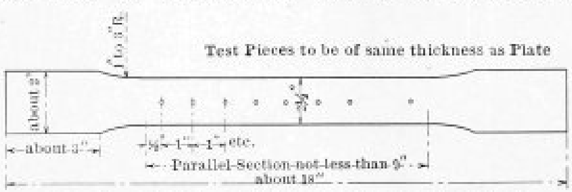


FIG. 14.—STANDARD TEST PIECE FOR BOILER PLATE.

elongation, 26 percent; cold and quench tests, 180 degrees flat on itself, without fracture on outside of bent portion; maximum phosphorus, .04 percent; maximum sulphur, .04 percent.

Fire-Box Steel.

Ultimate strength, 52,000 to 62,000 pounds per square inch; elastic limit, not less than one-half the ultimate strength; elongation, 26 percent; cold and quench bends, 180 degrees flat on itself, without fracture on outside of bent portion; maximum phosphorus, .04 percent; maximum sulphur, .04 percent.

Flange or Boiler Steel.

Ultimate strength, 55,000 to 65,000 pounds per square inch; elastic limit, not less than one-half the ultimate strength; elongation, 25 percent; cold and quench bends, 180 degrees flat on itself, without fracture on outside of bent portion; maximum phosphorus, .06 percent; maximum sulphur, .04 percent.

Steel for boiler rivets shall be made of the extra soft grade as specified above. All tests and inspections shall be made at place of manufacture prior to shipment. The tensile strength, limit of elasticity and ductility shall be determined from a standard test piece, cut from the finished material, the standard shape of this test piece for sheared plates to be as shown in cut, Fig. 14. Test coupons cut from other material than plates may be the same as those for the plates, or they may be planed or turned parallel throughout their entire length. The elongation shall be measured on an original length of 8 inches, except in rounds of ⅝ inch or less in diameter, in which case the elongation shall be measured in the length equal to eight times the diameter of section tested. Four coupon pieces shall be taken from each melt of finished material, two for tension and two for bending.

Material, which is to be used without annealing or further treatment, is to be tested in the condition in which it comes from the rolls. When material is to be annealed, or otherwise treated, before use, the specimen representing such material is to be similarly treated before testing. Every finished piece of steel shall be stamped with the melt number. All plates shall be free from surface defects, and to have a workmanlike finish.

Each boiler inspection and insurance company has its own specifications for the material which is used in boilers built according to its rules. These are all of the same general character as the set already quoted.

Having fully decided about the plates, and sent the order to the mills to be filled, we will now direct our attention to the flues. Tubular boilers derive their heating surface mostly from the flues. The smaller the flues the more that can be put in, and this naturally makes more heating surface. Locomotive boilers have small flues for this reason, as the ratio of heating surface to grate area in a locomotive boiler is greater than in tubular boilers. Tubes of tubular boilers are laid out in vertical and horizontal rows. It is customary in some districts to have a manhole in the front head. This is a splendid feature, as it permits of inside inspection as well as permitting the boiler to be thoroughly cleaned, and, furthermore, in case of repairs to the bottom of the shell the work can be done

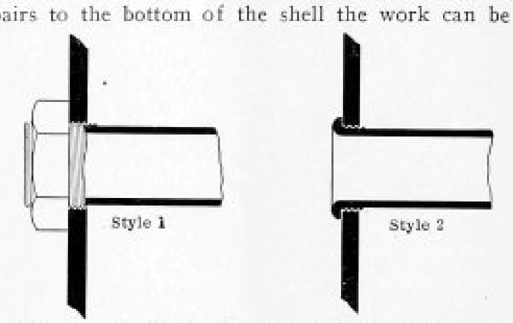


FIG. 2.—TWO METHODS OF FASTENING STAY-TUBES.

without removing the tubes, except in large repairs, when only a portion will have to be removed.

Layout of Tubes.

In Fig. 16 is shown the layout of 3-inch tubes, seventy-four in number. It will be noticed that there is a large space in the center. Many desire this, as they believe this space causes a better circulation of the water. Fig. 17 shows the layout of 3½-inch tubes, sixty-one in number. This layout, as will be noted, has one row in the center. Fig. 18 is the layout of 4-inch tubes, fifty-two in number. They are laid out with the same amount of space in the center as there is between the other rows of tubes. It will be noted in Figs. 16, 17 and 18 that on one side of the manhole the location of an end to end stay is shown, while on the other side is a flue shown dotted. The flue used in place of the end to end stay is a poor construction, as will be seen later on. When a manhole is not located in the front head, a greater number of flues can be placed in the boiler. For instance, if the manhole were omitted in Fig. 16 an additional row of flues could be put in, giving ten more flues; likewise in Fig. 17, two additional rows could be put in, giving thirteen more flues. In Fig. 18, one more row, making ten additional flues, could be used in place of the manhole.

Holding Qualities of Flues.

Experiments show that the holding qualities of flues expanded in the flue sheets vary very greatly. As the thickness of the head will have a bearing on this, no set rule can be made governing same. Much depends on the grade of workmanship performed. Ordinarily the flue expanded into the flue sheet will be perfectly safe. Experiments show that the mere beading of the flues increases the factor from 200 to 400 percent. This being the case, it is needless to say that this should be done when so much can be gained by so little trouble and work. If the flue could be fastened at the ends, so as to make the flue body the weakest point, it would be quite easy to figure out the strength of the flue and the stress to which it could be subjected. This could be figured in the same manner as the braces.

The holding qualities of flues has been proven as safe for boilers of small diameters, but large boilers should be stayed with stay-tubes. Fig. 19 shows two views of stay-tubes, with two modes of fastening them to the flue sheet. On the right-hand side, Fig. 19, view *B*, is the layout, showing the area that a stay-tube will support. The stay-tubes are shown with nuts, but can be applied as in view *A* by screwing into the sheet and beading over. There are two different values allowed, according to the method used. It will be seen that when the stay-tubes are laid out as in view *B* they form a much better support for the boundary rows of flues than in view *A*. Fig. 15 is an enlarged view, showing how the flues are fastened to the flue sheets.

The British marine rules for stay-tubes are as follows:

T = The thickness of plate is sixteenth of an inch.

P = The horizontal pitch, center to center of boundary rows.

C = Constant.

The formula is as follows:

$$\frac{C \times T \times T}{P \times P} = \text{working pressure.}$$

C = 120 when the stay-tubes are pitched with two plain tubes between them and not fitted with nuts on the outside of plates.

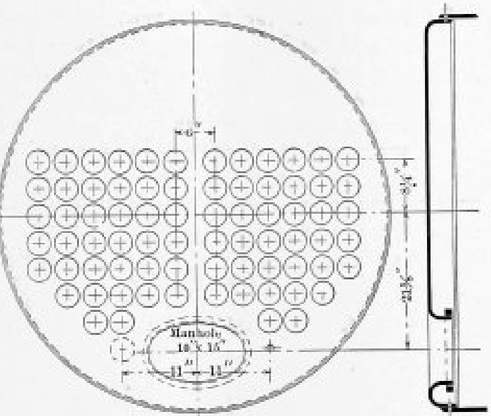
C = 130 when they have nuts on the outside of plate.

C = 140 if each alternate tube is a stay-tube not fitted with nuts.

C = 150 when they are fitted with nuts, outside the plates.

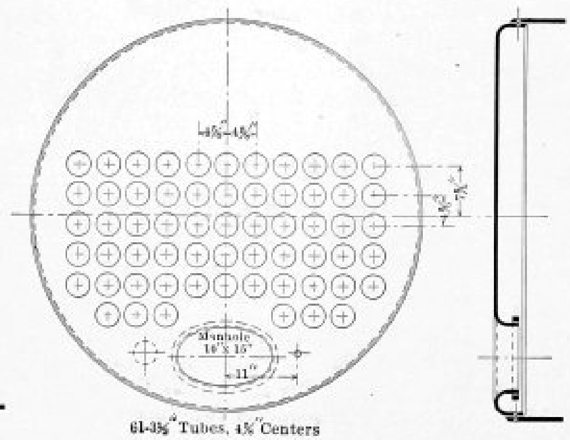
C = 160 if every tube is a stay-tube, and not fitted with nuts.

C = 170 if every tube in these rows is a stay-tube and each alternate stay-tube is fitted with nuts, outside the plates.



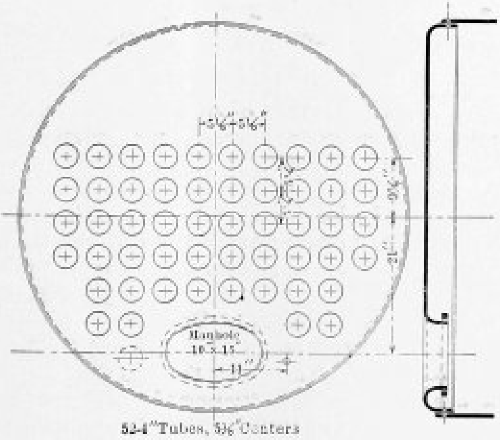
74-3" Tubes, 4⅛" Centers

FIG. 16.



61-3½" Tubes, 4⅝" Centers

FIG. 17.



52-4" Tubes, 5⅜" Centers

FIG. 18.

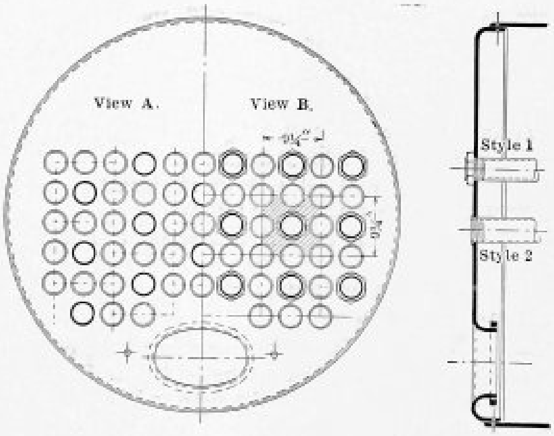


FIG. 19.

Assuming that the boiler had 3½-inch tubes, laid out as in Fig. 17, with ½-inch flue sheet and tubes fitted with nuts as in view B, every other tube being a plain tube, the working pressure would be found as follows. The constant in this case is 140:

$$\frac{140 \times 81}{85.6} = \frac{11{,}340}{85.6} = 132.5 \text{ pounds.}$$

Note.—Boilers of 60 inches diameter do not require stay-tubes.

What pressure is the stay-tube subjected to, laying aside any assistance derived from the plain tubes? As the centers of our tubes are 4⅝ inches, the stay-tube centers would be twice as great, or 9¼ inches. Thus 9¼ inches by 9¼ inches = 85.6 square inches. This would not be the actual area exposed to pressure, as there are some deductions to make, consisting of one 3½-inch hole, four half holes 3½ inches diameter, and four quarter holes, 3½ inches diameter. Adding these results together we have four 3½-inch holes. To find the area we multiply 3½ inches by 3½ inches by .7854 = 9.621 square inches.

The area of one tube being 9.621, the area of four tubes would be $4 \times 9.621 = 38.484$ square inches. Therefore, $85.6 - 38.484 = 47.116$ square inches.

Total pressure to each stay-tube is 47.116×175 pounds $= 8245.3$ pounds per stay-tube. Assuming that the metal of the stay-tube has 60,000 pounds tensile strength per square inch, let us see if a tube 1/8 inch thick is thick enough.

Three-inch flue, 1/8 inch thick, equals 3¼ inches inside diameter and 3⅜ inches neutral diameter. Thus, 60,000 × 1/8 inch × 3⅜ inches × 3.1416 = 79,500.

$$\frac{79{,}500}{8245.3} = 9.64 \text{ factor.}$$

Thus we see that stay-tubes 1/8 inch thick are thick enough. Since tubes are in a measure braces they should have a factor as high as braces which is figured as 7 or 8.

Heating Surface.

The heating surface of a boiler includes the tubes and the parts of the shell and heads which are exposed to the flames and gases. The following general rule for calculating the amount of heating surface covers all parts exposed to the flames and gases:

Multiply two-thirds of the circumference of the shell in inches by its length in inches. Multiply the number of tubes by the length in inches. Multiply this product by the inside diameter × 3.1416. Add to these products two-thirds of the area of the tube sheets or heads. Then subtract from this sum twice the area of the tubes. This product gives the number of square inches. To find the number of square feet divide by 144. Take as an example, the boiler with the layout of tubes 3 inches diameter, seventy-four in number:

A = Circumference of shell in inches.
B = Length of shell in inches.
C = Heating surface of shell in square inches.
D = Circumference of tube in inches.
E = Heating surface of tubes in square inches.
F = Area of one head in square inches.
G = Two-thirds of the area of both heads in square inches.
H = Area of all tubes in square inches.
I = Total heating surface.

Some mechanical engineers figure that the area of the head should be figured from the outside diameter of the boiler, while others the outside diameter of the head, which is the inside diameter of the boiler. This, however, does not have a great bearing on the final number of square feet.

Working out the boiler to the letters A, B, C, D, E, F, G, H and I we will have the following:

A = 60⅞ inches × 3.1416 = 191.25 inches.
B = 14 feet × 12 inches = 168 inches.
C = 191.25 × 168 × 2/3 = 21,420 square inches.
D = 2¾ inches × 3.1416 = 8.64 inches.
E = 74 × 168 × 8.64 inches = 107412.48 square inches.
F = 60⅞ × 60⅞ × .7854 = 2910.5 square inches.
G = 2/3 × 2 × 2910.5 square inches = 3880.66 square inches.
H = 2¾ inches × 2¾ inches × 74 × .7854 = 439.52 square inches.

Thus our formula will read as follows:

$$\frac{C + E + G - 2 \times H}{144} = I$$

Substituting values, we have

$$\frac{21{,}420 + 107{,}412.48 + 3880.66 - 2 \times 439.52}{144} = 915.55 \text{ sq. ft.}$$

EXPLANATION OF BURSTING AND COLLAPSING PRESSURE.

Flues are subjected to external pressure, while the boiler shell is subjected to internal pressure. There is considerable difference between them. Excess pressure on a boiler shell will result in bursting the shell, while on a flue it will cause a collapse. The shell of a boiler may be out of round but the pressure will tend to round it out to its true shape unless the shell is braced to resist such a stress.

The pressure on a flue being equal on all sides, it would appear reasonable to presume that the pressure on one side would offset the pressure on the other side. This is not actually the case, however, as the working of the boiler causes shocks, and once the flue assumes any shape other than that of a perfectly true cylinder, it is easy prey to the pressure and will result in a collapse.

This explanation will show the prime necessity of having all flues and furnaces that are subjected to external pressure made perfectly true in diameter. The United States allows 225 pounds pressure on all lap-welded flues up to 6 inches diameter, if the material conforms to the following table:

O. Dia. Ins.	Thickness. Ins.	O. Dia. Ins.	Thickness. Ins.	O. Dia. Ins.	Thickness. Ins.
1	.072	3¼	.120	9	.180
1¼	.072	3½	.120	10	.203
1½	.083	3¾	.120	11	.220
1¾	.095	4	.134	12	.229
2	.095	4½	.134	13	.238
2¼	.095	5	.148	14	.248
2½	.109	6	.165	15	.259
2¾	.109	7	.165	16	.270
3	.109	8	.165	....	....

Flues above 6 inches diameter are allowed other values.

COLLAPSING PRESSURES OF FLUES.

Prof. Reid T. Stewart, of Allegheny, Pa., has conducted extensive experiments to ascertain the collapsing pressures of flues, and has deduced several formulæ, which tend to show that all previous formulæ are more or less incorrect. The general practice has been to take into consideration the length of the flue or furnace from end to end, ring to ring or joint to joint. Figuring on the total length has been found as incorrect, as flues and furnaces do not collapse their entire length.

Experiments conducted by Prof. Stewart demonstrate that long flues will collapse at one point and the balance of flue be perfectly true. The extent that the rigid ends will support the flue cannot be fully determined. It is true that when the flue or furnace is of great length it derives no assistance from the rigid ends. The assistance derived from the rigid ends cannot be taken into consideration, as it does not extend far enough to be accepted as any value.

After a great many tests Prof. Stewart has advanced the following formula B:

$$P = 86{,}670 \frac{T}{D} - 1{,}386. \qquad (B)$$

P = Collapsing pressure in pounds per square inch.
D = Outside diameter of tube in inches.
T = Thickness of wall in inches.

Formula A:

$$P = 1000 \left(1 - \sqrt{1 - 1600 \frac{(T)^2}{(D)^2}} \right) \qquad (A)$$

Formula A is for values less than 581 pounds, or for values of $\frac{T}{D}$ less than 0.023. Formula B is for values greater than these.

Prof. A. P. Carman, of the University of Illinois, has conducted experiments upon the collapsing of flues, and has advanced the following formulæ:

$$P = 50{,}200{,}000 \frac{(T)^3}{D}$$ for thin, cold-drawn seamless tubes.

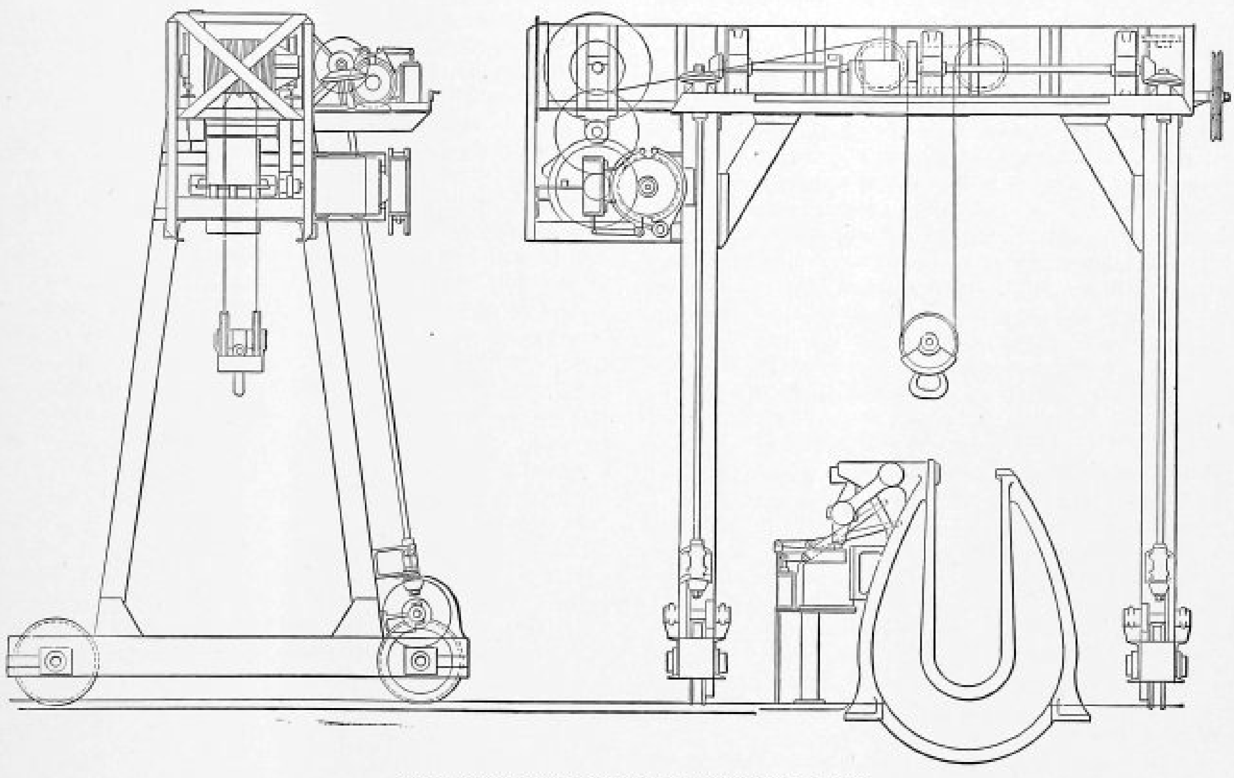
$$P. = 95{,}520 \frac{T}{D} - 2{,}090$$ for seamless cold-drawn tubes

having a ratio of $\frac{T}{D}$ greater than .03.

A formula advocated is to add to the length of the furnace expressed in feet the unit 1. Taking the British Columbia Rule, we have

$$\frac{C \times T^2}{(L + 1) \times D} = B$$

It will be seen that the length represented by (L) has added to it the unit (1). The adding of the unit (1) is not correct, as it will readily be seen that if the length of the furnace is 3 feet an increase of 33 1/3 percent has been added, or if the furnace is 4 feet long and the unit (1) is added, the increase is 25 percent. It is quite apparent that the further the center of the furnace or tube is from the rigid ends the less support they receive from this source. The first foot of flue or furnace is naturally more benefited than the next foot. This continues this way until the flue or furnace receives no benefit from the rigid ends. In furnaces this is taken care of by rings and joints of several different forms. In boiler flues the rigid ends are not taken into consideration, for the reason that boiler tubes will collapse at one place and the balance of tube be perfectly in its true shape.



SIDE AND END ELEVATIONS OF A RIVETING GANTRY.

C = Constant.
T = Thickness of plate in inches.
L = Length of furnace in feet.
B = Working pressure per square inch, which must not exceed the value $\frac{1{,}000 \times T}{D}$

11,250 is allowed for the constant (C) when the longitudinal seam is welded or fitted with double butt straps, single riveted.

FORMULÆ.	Diameter of Flue.	Thickness of Flue.	Collapsing Press.	Style of Flue.
$P = \frac{86670\,T}{D} - 1386$	3"	.109	1763	Lap weld Bessemer steel
	3½"	.120	1585	
	4"	.134	1517	
$P = \frac{95520\,T}{D} - 2090$	3"	.109	1348	Seamless cold drawn steel.
	3½"	.120	1176	
	4"	.134	1100	

A Riveting Gantry.

There are many different kinds of riveter installations, each of which has some special advantages for certain types of work. The traveling gantry herewith illustrated can be installed with either an hydraulic or pneumatic stationary riveter or it can be used for the suspension of a portable riveter. The gantry consists of two vertical A frames mounted upon wheels and carrying the frame work upon which an electrically-driven crab may run. By means of an inclined shaft and bevel gears the gantry can be moved along the track upon which it rests, giving the motion in one direction while the crab travels at right angles to this. The entire movement of the gantry may be controlled from the riveter platform or from a cage on the gantry.

While this arrangement requires considerable floor space yet it is well suited for use where the construction of the building will not permit the installation of overhead cranes. This gantry is designed and built by the Standard Bridge Tool Company, Pittsburg, Pa.

Brittleness in Steel.*

Observations Made in English Boiler Plate Practice.

BY C. E. STROMEYER.

The past year or two the confidence placed by the engineering world in mild steel has been shaken by a few failures for which as yet no satisfactory explanations have been found; but inquiries have been set on foot, of which it is hoped that if they do not throw any light on the true cause they may at least point to some test which will discover the doubtful material before it gets into the hands of the boiler maker.

When, at the end of the seventies, mild qualities of steel were first made in the open hearth furnaces, it was hoped that a more reliable substitute had been found for iron than Bessemer steel could claim to be; and after a short experience, especially on war vessels, the French and English Admiralties, followed by Lloyd's Register, fixed on certain quality tests which, so it was hoped, would discriminate between reliable and unreliable steel, or rather between open hearth and converter steel. In those days the chief cause of unreliability was believed to be the unequal distribution of carbon in Bessemer steel, and the most effective conditions for excluding this steel were that the material should have a high tenacity, say, 25 tons and upward; a good elongation, say, above 20 percent, and the material should show no sign of brittleness after being heated to a bright red heat and plunged into water of 28 degrees C. or 82 degrees F. By this means the use of the somewhat uncertain Bessemer steel was practically stopped for ship and boiler plates; but in spite of careful testing, iron never having been tested to the same extent, alarming failures were still experienced. The best known of these was the breaking of the shell plates of the boilers intended for the Imperial Russian yacht Livadia. It will be remembered that after some of her boilers had been built, one of them burst while being tested, and others were found to be fractured before testing, and these plates, which had stood the workshop practice, broke while being taken to pieces. The nature of the process by which the steel was made was not divulged, but that it led to irregular distribution of constituents was evident from a series of analyses, of which, one set was made on the different layers of one sample, ⅞ inch thick. The carbon ranged from 0.09 to 0.20; the sulphur from 0.018 to 0.123; the phosphorus from 0.039 to 0.079, and the manganese from 0.230 to 0.410.

In another sample, whose fracture showed very marked segregations, the carbon varied from a trace on one side to 0.050, 0.070 and 0.100 on the other side.

The tensile tests of the fractured plates varied from 29¼ tons to 34¼ tons tenacity, and elongations of from 11¾ to 23.9 percent in 8 inches, except that some samples cut out between the punched rivet holes were quite brittle.

Shortly after this failure Mr. Maginnis published details about the failure of some other marine boilers which had been at work for two and one-half years. He says:

"1. The material used for two different sets of boilers, each set consisting of three circular boilers with horizontal steam chests, passed all tests required by the Board of Trade and Lloyd's. 2. The material stood without the slightest defect the ordinary work of the boiler shop, including welding, etc. 3. Each set of boilers worked satisfactorily at sea for a period of two and one-half years, after which they then exhibited signs that a complete change had taken place in the nature of the steel.

"Apparently the boiler plates had become absolutely brittle. The tenacities of the original plates varied from 26¼ tons to 30¼ tons, with elongations of from 19¾ percent to 27 percent. The tensile tests of plates cut from the fractured combustion chambers, of which only two original tests are included in the above, showed tenacities of 25 tons, 26 tons and 45 tons, with elongations up to 27 percent for the first two, and up to 15 percent for the hard plate."

When about the time of these failures I discovered that mild steel could be made permanently brittle by merely heating it to a temperature of melting lead and bending and hammering it, hopes were entertained that similar failures could now be explained, but there are evidently other causes than working steel at a blue heat which will produce brittleness, and one which was very early recognized was the presence of phosphorus in the steel in excess of, say, 0.07 percent.

A notable case of three ships being built of this quality of steel soon drew renewed attention to the danger of using it. Two of these ships were launched and went to sea; but fractures of their beams and angle irons were so frequent that an inquiry was made into the condition of the third ship, which was still on the stocks. It was found that nearly every frame and beam could be broken by heavy blows of a hammer, and that, too, in spite of the fact that these parts had shown no signs of brittleness when new, lending themselves to bending, punching, drilling, hammering and riveting operations without either breaking or cracking. This steel had been made by the basic Bessemer converter.

It is well known that elastic sulphur will, after a time, change into a brittle crystalline form, and in Sheffield the opinion is almost universally held that the steel made there improves by years of keeping. Why should not other qualities change and perhaps deteriorate? At any rate, my subsequent experiences have tended strongly to confirm this view.

The general opinion is that brittleness, due to heat treatment, can be removed by renewed judicious heating, especially if accompanied by hammering or rolling, from which it would follow that the last heating process to which a piece of steel is subjected would have an all-important effect. Others seem to hold that every heat treatment through which a piece of steel passes leaves its mark. According to this view the temperature at which a charge is cast should influence its qualities. This is in a measure confirmed by differences of tenacity of steels of the same chemical composition, but made at different works, and also by the great difference of quality between the purest wrought iron and the purest steels. The former material has never been heated above a welding temperature; the latter has been in a molten condition. If this view is correct, then even the temperature of the furnace used for reheating before rolling should affect the quality of the finished article. This may have been the cause of a recent failure of another plate.

It had been satisfactorily tested at the steel works, and being intended for butt straps it was being sheared again at the boiler works, when, to the surprise of everybody, these strips broke and fell off in bits. All the plates from the same cast were at once rejected, but no tests to which they were then subjected, nor yet the chemical analysis, revealed anything wrong.

The defective plate behaved very unreasonably. As already mentioned, the strips which were sheared off in the boiler yard fell to pieces, but those sheared off subsequently at the steel works were perfectly ductile and could be bent as close as any other samples. These latter samples had been sheared off the same end as the rest and the shearing edge was comparatively new. When strips were sheared off the other edges, which had not been touched since the plates left the steel works, were also found to be brittle. Evidently, then the injury done to the extreme edge by shearing was slowly spreading into this plate, but the shears were not to blame, for the other plates were good. There was evidently something in

* Annual report for 1905 to the Manchester Steam Users' Association, Manchester, England.

the quality of this steel which made it sensitive to this severe treatment, and unquestionably, therefore, it was not a suitable material to use, but how it acquired this peculiar quality was not discovered.

In view of the possibility of these occurrences this association may be congratulated on its system of check testing, which seems to be specially adapted for detecting changes which may be slowly progressing. When a boiler is being built under our inspection, check tests are made with samples cut from certain plates, and these should, of course, reveal whether the material has grown brittle since it left the steel works. Check tests applied to the plates of Maginnis's boilers, or to the angles of the brittle ships previously referred to, would, it is fairly safe to say, have revealed that a change for the worse was taking place.

A case of great interest, but one about which full details cannot unfortunately be obtained, occurred about two years ago in Russia. Some Lancashire boilers had been at work for six years, and were annually tested by hydraulic pressure in accordance with government regulations. On the occasion of the sixth test one boiler burst, and one year later the adjoining boiler burst.

Although the material was not of first-class quality, one would hardly expect brittleness with a percentage of 0.121 percent carbon and 0.07 percent phosphorus; on the contrary, the analysis would lead one to expect the results which were actually obtained, namely, mean tenacity 23 tons, elongation 28 percent in 8 inches.

Another class of fractures which may possibly be influenced by the chemical composition of the material and by improper heat treatment is caused by excessive and repeated straining, generally called fatigue. Plates which have been flanged round their edges and laid aside, sometimes crack when the circumferences have cooled. Thick forgings sometimes crack while being machined, and an armor plate once broke in two, evidently due to a similar cause. These, or somewhat similar results, are produced in boiler end plates and furnace flanges due to excessive heating of the furnace plates, brought about in most cases by grease in the feed and sometimes by scale. This trouble was not serious as long as boiler pressures were low and boiler plates thin and elastic, but the increased pressures demand increased strength, which, if the design is not altered, is accompanied by increased rigidity and liability to fracture.

Rules for the Management and Care of Steam Boilers.

The following rules are prescribed by the Casualty Company of America, 52-54 William street, New York, for the management and care of all steam boilers insured in their company:

First.—On entering the boiler room ascertain, beyond doubt, the quantity of water in the boiler you are using before attending to any other duty.

Second.—Keep the gage cocks clean, and open them frequently. Do not rely upon glass gages or automatic alarms, as they are intended only as auxiliaries.

Third.—Keep the boilers dry on the outside. Do not permit any water or leaks from pipes to come in contact with the outside shell. Have all such leaks repaired at once.

Fourth.—Look for blisters on the fire sheets, and if any are noticed have the plates cleaned and examined carefully.

Fifth.—Keep all internal parts of the boiler exposed to fire perfectly clean. The boiler should be kept free from scale, as this presents increased liability of plates to burn or crack and is frequently the cause of an explosion. The safety valve should be raised frequently and carefully as it is liable to stick in its seat and would then be useless for the purpose intended.

Sixth.—When the pressure gage indicates the limit stipulated in the inspection certificate of the Casualty Company of America, the safety valve should be blowing off. If not, notify the company and have the steam gage tested and the valve reset.

Seventh.—If the feed-water is bad, the boiler should be blown down three or four inches at regular intervals. Boilers that have fires banked all night should be blown down 3 or 4 inches every morning.

Eighth.—In case of low water, bank the fire with wet ashes or fresh coal, closing the ash-pit doors. Do not turn on the feed under any circumstances nor tamper with or open safety valves. Let the steam outlets remain as they are until the boiler has cooled off.

Ninth.—Do not close the damper entirely while there is fire in the grate as the gases may collect in the tubes and uptakes and result in an explosion.

Tenth.—In case of foaming, close the throttle and keep it closed long enough to find out the true level of the water. If that level is sufficiently high, feeding and blowing will usually suffice to correct the trouble. In case of violent foaming, caused by dirty water, in addition to the action above stated, check the draft and cover the fire with fresh coal or ashes.

Eleventh.—When intending to blow-off for repairs or internal inspection, clean the furnace and bridge wall of all coal and ashes. Allow the brickwork to cool down before opening the blow-off valve. The boiler should be blown off at a pressure not exceeding twenty (20) pounds. After blowing down, allow the boiler to become cool before filling again. Cold water pumped into hot boilers is very injurious. Under all circumstances, keep all gage cocks, etc., clean and in good order and things generally in and about boiler room in neat condition.

Twelfth.—In preparing to get up steam after boilers have been out of service for some time, great care should be exercised in making the man and hand-hole joints. The safety valve should be opened and blocked up, and the necessary supply of water run or pumped into the boilers, until it shows at the second gage in tubular or locomotive boilers; in vertical boilers a higher water level should be given in order to protect the top ends of the tubes.

After this is done, fuel may be placed upon the grate, the dampers opened and a fire started. If the chimney or stack is cold and does not draw properly, burn some light kindlings at the base. Start the fires in plenty of time, so that it will be unnecessary to force the boiler. When steam begins to issue from the safety valve, lower it carefully to its seat and take a note of the pressure on the steam gage.

If there are other boilers in operation and stop valves are to be opened to place the boilers in connection with others on the same steam-pipe line, watch those recently fired up very carefully until the pressure accords with that of the other boilers to which they are to be connected, and when the pressure is equal, open the stop valves very slowly and carefully.

Inspectors will give special instructions in cases not covered by these rules. If the boiler shows distress or unusual behavior, notify the company's agent at once.

Advantages of Mechanical Draft for Steam Boilers.

External temperature changes have no appreciable effect upon the operation of a mechanical-draft plant, which above all else is independent of climatic changes and conditions. The fan is a most important factor in smoke prevention, and in connection with the closed fire-room system the resulting ventilation is of vital importance.

Briefly summarized, mechanical draft is capable of reducing the avoidable losses, of decreasing the first cost of a steam generating plant, and of reducing the fuel expense. In addition it presents certain marked conveniences in the matter of installation and operation. In these days when every step in the process of steam generation and utilization is being scrutinized in the attempt to reduce the cost by even a single per-cent the opportunity presented by the employment of mechanical draft cannot be and is not overlooked. The economical necessity was not so imperative when Rankine and Clark, half a century ago, pointed out its marked advantages. And the future was but dimly discerned when, only twenty years ago, Seaton referred to the chimney as rough and ready, but exceedingly wasteful as a way of inducing the air to flow into furnaces with sufficient velocity to cause the fuel to burn, and prophesied that it would some day undoubtedly be superseded b/ a more scientific and economical apparatus.

What these men foresaw, we to-day realize. Mechanical draft now stands so well established in the engineering world as to lead a noted engineer to remark that "the building of tall chimneys to secure draft simply advertises the owner's lack of familiarity with modern improvements, or his want of confidence in results easily demonstrated."—*Power.*

Locomotive Boiler Tubes.

Heating Surface.—Table No. 1 affords a convenient means of quickly finding the total heating surface of the tubes in a boiler. The heating surface in square feet is given for tubes from 11 to 26 feet in length and from 1½ to 2½ inches in diameter, also the same information for each inch up to a foot in length and for fractions of an inch varying by sixteenths. In using the table, add together the heating surface for the feet, inches and fraction of an inch for one tube and multiply by the number of tubes.

Fire Area.—The total fire area of the tubes in a boiler may quickly be found by means of table No. 2. This shows the fire area for from one to ten tubes of various gages and from 1¾ to 2½ inches in diameter. As an example, to find the fire area of 548 2-inch tubes, No. 12 gage: Under 2-inch tubes, No. 12 gage, find the area for five tubes and move the decimal point two places to the right (1245); add to this the area for four tubes with the decimal point moved one place to the right (99.6), and the area for eight tubes (19.9), which gives a total of 1,364.5 square feet.

Length and Weight of Tubes.—The accompanying chart affords a quick and convenient means of estimating the length and weight of the tubes in a boiler. The item of the weight of tubes becomes an important one in the design of locomotives where the weights have to be held strictly within given limits, and it is sometimes necessary to change the gage in the thickness of the tubes to enable the designer to keep within the weight limit and still retain the desired total heating surface. Starting at the top of the diagram with the given number of tubes, follow the line vertically until it intersects the diagonal of the given length of the tubes (for calculating weights of aggregate lengths, this length should be taken as 1 inch more than the normal length to allow for beading), follow the horizontal line at this intersection until it intersects the diagonal of the given diameter and gage and thence to the bottom of the chart, where the total weight may be read. To obtain the aggregate length of the flues, follow the horizontal from the intersection of the vertical for the number of tubes and the diagonal for the length of the tubes to the left side of the diagram. Lines on the chart show the method of finding the length and weight of 365 tubes 20 feet long, 2¼ inches, outside diameter. The total length is about 7,300 feet and they weigh about 18,400 pounds. These weights are based

TABLE No. 1.
HEATING SURFACE OF FLUES IN SQUARE FEET.

Outside Diameter of Flues.	Length in Feet. 11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1½	4.316	4.709	5.101	5.494	5.886	6.278	6.071	7.062	7.455	7.848	8.240	8.633	9.025	9.418	9.810	10.202
1¾	5.040	5.498	5.956	6.415	6.873	7.331	7.789	8.247	8.706	9.164	9.622	10.080	10.538	10.997	11.455	11.913
2	5.760	6.283	6.807	7.330	7.854	8.377	8.901	9.425	9.948	10.472	10.995	11.519	12.043	12.566	13.090	13.613
2¼	6.476	7.064	7.653	8.242	8.830	9.419	10.008	10.596	11.185	11.774	12.363	12.951	13.540	14.129	14.717	15.306
2½	7.199	7.854	8.508	9.163	9.817	10.472	11.126	11.781	12.435	13.090	13.744	14.399	15.053	15.708	16.362	17.017

Outside Diameter of Flues.	Length in Inches. 1	2	3	4	5	6	7	8	9	10	11	12
1½	.033	.065	.097	.131	.164	.196	.229	.260	.294	.327	.360	.392
1¾	.038	.076	.114	.152	.191	.229	.267	.305	.342	.382	.418	.458
2	.044	.087	.131	.174	.218	.262	.305	.349	.392	.436	.479	.528
2¼	.049	.098	.147	.196	.245	.294	.343	.393	.442	.491	.539	.589
2½	.054	.119	.163	.218	.272	.327	.381	.436	.490	.540	.599	.654

Outside Diameter of Flues.	Length in Fractions of an Inch. 1-16	⅛	3-16	¼	5-16	⅜	7-16	½	9-16	⅝	11-16	¾	13-16	⅞	15-16
1½	.002	.004	.006	.008	.010	.012	.014	.016	.018	.020	.022	.024	.026	.028	.031
1¾	.002	.005	.007	.009	.012	.014	.017	.019	.021	.024	.026	.028	.031	.033	.036
2	.003	.005	.008	.011	.013	.016	.019	.022	.024	.027	.030	.033	.035	.038	.041
2¼	.003	.006	.009	.012	.015	.018	.021	.024	.028	.031	.034	.037	.040	.043	.046
2½	.003	.007	.010	.014	.017	.020	.024	.027	.031	.034	.037	.041	.044	.048	.051

TABLE No. 2.
FIRE AREA OF TUBES.

Diameter in Inches.	1¾			2			2¼		
Gage	13	12	11	13	12	11	13	12	11
Area 1 tube	1.917	1.84	1.767	2.58	2.49	2.405	3.341	3.24	3.142
Area 2 tubes	3.834	3.68	3.534	5.16	4.98	4.810	6.682	6.48	6.283
Area 3 tubes	5.751	5.52	5.301	7.74	7.47	7.215	10.023	9.72	9.425
Area 4 tubes	7.668	7.36	7.068	10.32	9.96	9.620	13.364	12.96	12.566
Area 5 tubes	9.585	9.20	8.835	12.90	12.45	12.025	16.705	16.20	15.708
Area 6 tubes	11.502	11.04	10.602	15.48	14.94	14.430	20.046	19.44	18.849
Area 7 tubes	13.419	12.88	12.369	18.06	17.43	16.835	23.387	22.68	21.991
Area 8 tubes	15.336	14.72	13.136	20.64	19.92	19.240	26.728	25.92	25.133
Area 9 tubes	17.253	16.56	15.903	23.22	22.41	21.645	30.069	29.16	28.274

on the nominal weights of the tubes plus 2½ percent to allow for overweight. This gives the following weights per foot: 2.22 pounds for 2 inch No. 12; 2.44 pounds for 2 inch No. 11; 2.52 pounds for 2¼ inch No. 12; 2.77 pounds for 2¼ inch No. 11.—*American Engineer and Railroad Journal.*

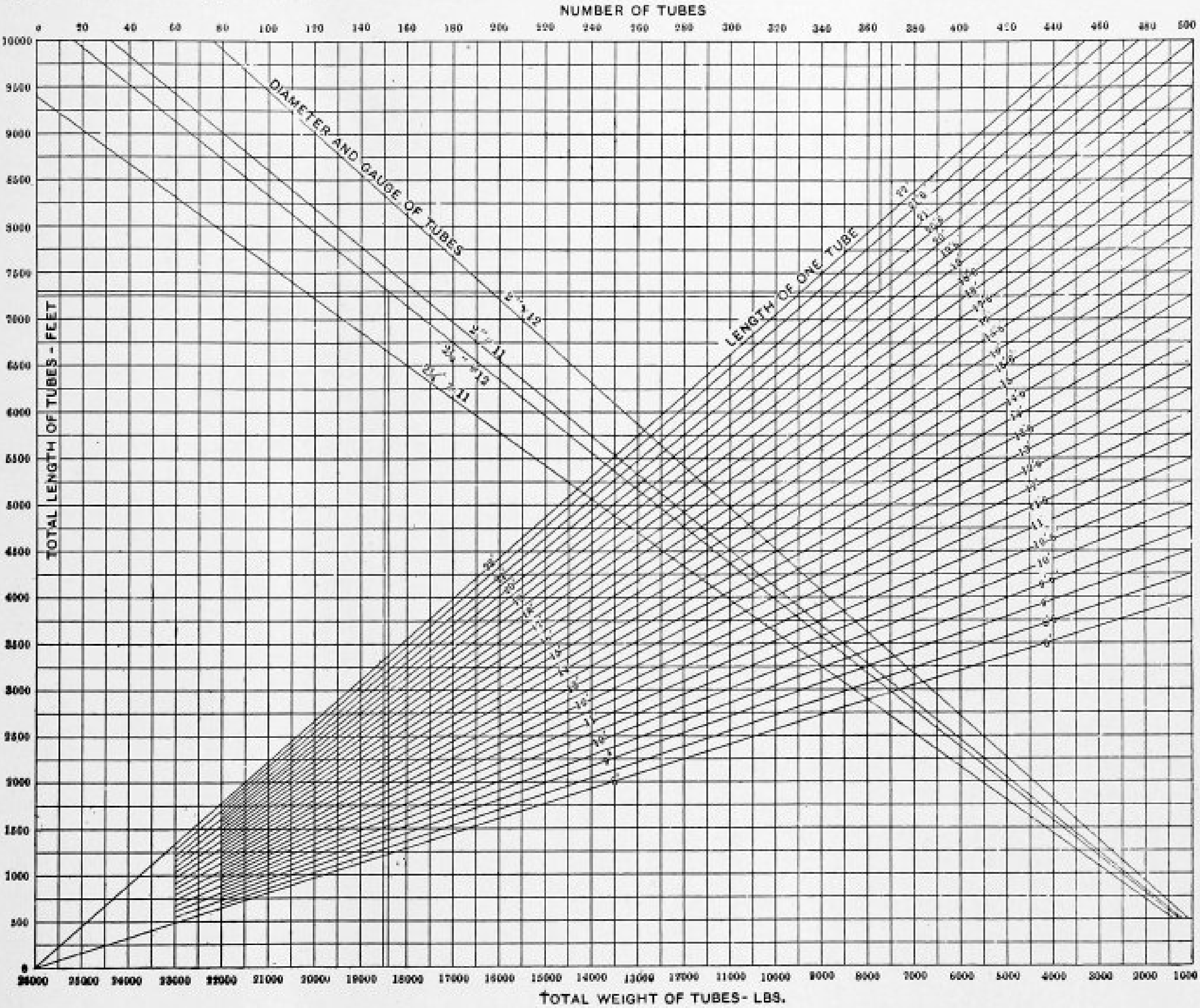


CHART GIVING THE TOTAL LENGTH AND WEIGHT OF DIFFERENT SIZE TUBES IN A LOCOMOTIVE BOILER.

Program.

The proposed program for the joint convention of the I. R. M. B. M. A. and M. S. B. M. A., to be held at Cleveland, Ohio, May 21, 22 and 23, 1907, is as follows:

May 21st:

Convention assemblies at................ 10:00 a.m.
Opening exercises.................. 10:00 to 10:15 a.m.
Address of welcome................. 10:15 to 10:45 a.m.
Address by prominent railroad official (introduced by President Hempel)....... 10:45 to 11:15 a.m.
Reply to address by President Smyth.... } Address by expert railroad club secretary (introduced by President Smythe)...... } 11:15 to 11:45 a.m.
Reply to address by President Hempel.... } President Smythe's address............. } 11:45 to 12:00 noon
President Hempel's address.............. 12:00 to 12:15 p.m.

Secretaries to make announcements including committees appointed to serve during convention.

Adjourn.

Assemble in hotel lobby at 2:00 p.m. to spend afternoon socially, in manner to be arranged later.

Banquet.................................. 7:00 p.m.

Evening entertainment to be arranged later.

May 22d:

Convention called to order............... 9:30 a.m.
Unfinished business..................... 9:30 to 10:00 a.m.
New business........................... 10:00 to 10:30 a.m.
Papers to be read, and subjects opened for discussion........................... } 10:30 to 12:00 noon; 2:00 to 5:00 p.m.

Four subjects to be provided, two from each Association, advanced papers in printed form to be in the hands of all members thirty (30) days before convention.

May 23d:

Convention called to order............... 9:30 a.m.
Open discussion of shop practices......... 9:30 to 12:00 noon
Subjects to be discussed to be in the hands of Presiding Officer before the close of second day's session.
Reports of treasurers and secretaries..... 2:00 p.m.
Reports of auditing committees.
Election of officers.
Closing remarks.
Convention adjourned.

Signed, J. H. SMYTHE,
President M. S. B. M. A.

E. S. FITZSIMMONS, Chairman, Executive Committee, M. S. B. M. A.
G. WAGSTAFF, Chairman, Executive Committee, I. R. M. B. M. A.
G. BENNETT, Member, Executive Committee, I. R. M. B. M. A.

Only two subjects will be discussed by each association, the remaining time being devoted to organization, entertainment, etc. The topic which will be presented by the Master Steam Boiler Makers' Association is "Steel vs. Iron Flues for Locomotive Boilers." This report will cover all successful methods of welding and setting flues; a comparison between iron and steel for service; the milcage obtained between renewals, and, if possible, analysis of the water used in working as well as any other information which can be obtained. The committee, which has this topic in charge, is composed of Mr. Frank Gray, chairman; W. W. Wilson, P. S. Morrison, G. G. Nicol, P. J. Conrath and J. L. Meyers.

The topic which will be presented by the International Railway Master Boiler Makers' Association is "Hydrostatic Tests of Boilers, Including Hot and Cold Water Tests." This discussion will cover recommendations for excess pressure, for time period between tests at various ages of the boiler, the benefits derived from difficulties encountered from tests with hot and cold water as well as all similar information obtainable bearing upon this subject. The committee which has this topic under consideration is composed of Mr. E. S Fitzsimmons, chairman; J. J. Fletcher, William Horsley, T. W. Lowe and Walter Singer.

Elementary Problems.

CONICAL SURFACES WHERE THE TAPER IS SMALL.

There are many cases in boiler making where it is necesary to lay out a plate which, when it is rolled up, will have the form of the frustum of a right circular cone, the taper of which is very slight. An example of this is shown in Fig. 31, where there is little difference between the diameters of the upper and lower bases of the frustum. This means that the slant

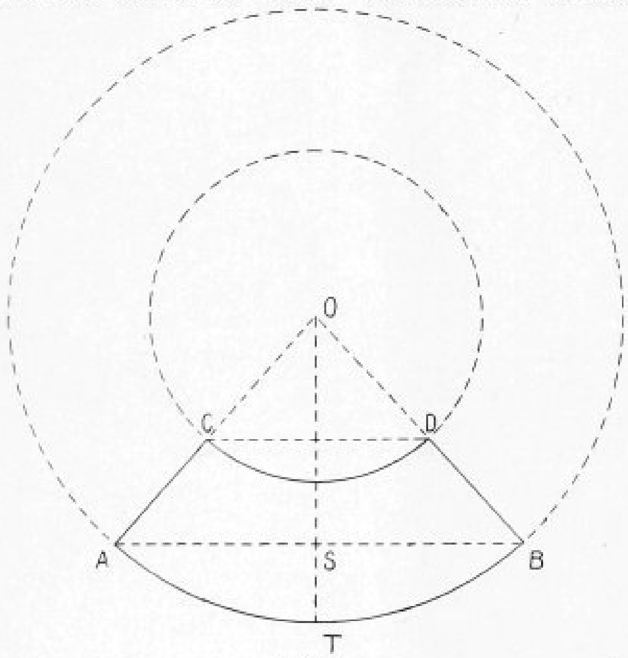


FIG. 30.

height of the cone is very large. In the case of Fig. 31 it would be about sixty.

The layout of such a plate where the slant height is not too great to be used as a radius, is shown in Fig. 30. Of course, the upper and lower edges of the plate are arcs of circles drawn from the same center with a radius equal to the distance of the respective bases from the apex of the cone. The curved lines *ATB* and *CD* are, of course, equal in length to the respective circumferences of the two bases. Now, it will be seen that where the distance *AO* is too great to be used in the shop when laying out the plate full size; that is, if it were 30 or 40 feet, the plate might be laid out by drawing the Fig. *ACDB*, if the distance *ST*, commonly known as the rise or camber of the sheet, can be found.

The distance *ST* is often called by boiler makers the versed sine, without much knowledge of what this function is. In reality the versed sine is a trigomometric function of an angle, and in the case of Fig. 30 the ratio $\frac{ST}{OB}$ is the versed sine of the angle *SOB*. The distance *ST* itself should not be called a versed sine, and the versed sine of the angle *SOB* will never equal the distance *ST* except when the radius *OB* is unity. If the length of the radius *OB* is known the distance *ST* may be found by multiplying *OB* by the versed sine of the angle *SOB*.

This distance, however, may be found graphically as well as by calculation, thus enabling one to lay out the sheet without striking in the curves *CD* and *AB* from the apex of the cone. There are many different methods for laying out this

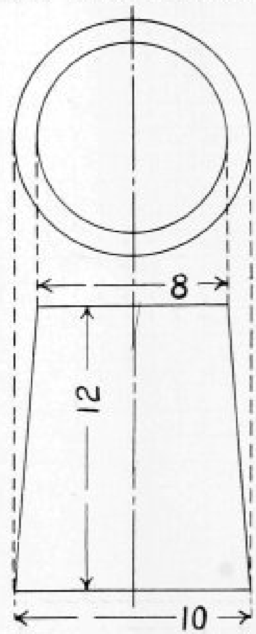


FIG. 31.

form of sheet, and most of them are absolutely correct. Some few are only approximately correct, but since the taper of the ring is always small, the camber or distance *ST* is always small, and, therefore, the approximate method will be sufficiently accurate for ordinary purposes.

Two methods in common use for this layout are given herewith. Consider the frustum shown in Fig. 31, whose height is 12, the diameter at the top being 8 and that at the bottom being 10. The length of the sheet along the top edge will be the circumference of a circle whose diameter is 8, or $3.1416 \times 8 = 25.14$. The length of the bottom edge of the sheet is the circumference of a circle whose diameter is 10, or $3.1416 \times 10 = 31.416$. The width of the sheet must be computed, since the height of the frustum between bases is given. The width of the sheet or the slant height of the frustum is the hypotenuse of a right triangle, one leg of which is 12 and the other one-half the difference between the diameters of the lower and upper bases, or $\frac{1}{2}(10 - 8) = 1$. Therefore, the width of the plate equals $\sqrt{12^2 + 1^2} = \sqrt{145} = 12.04$.

Referring to Fig. 32, it will be seen that we now have the following dimensions:

The length of the top edge of the plate	= 25.14
The length of the lower edge of the plate	= 31.416
The width of the plate	= 12.04

In order to lay out Fig. 32 we must know the distance between the upper and lower edges. This will be found from the right triangle shown dotted at the left of the figure, or it is equal to the $\sqrt{12.04^2 - 3.138^2} = 11.62$.

Having found these dimensions the diagram *ABDC*, Fig. 33, may be laid out according to them. It is then necessary to construct on the lines *AB* and *CD*, as chords, the arcs of the circles, which are the true development of the upper and lower edges of the plate. It, therefore, becomes necessary to find the distance *DE* or the camber of the plate. To do this, with a straight edge and square, square up from *D* the center of the line *CD*, the line *SD* to the line *AC*. With *D* as a center set the trams to the line *SD* and draw an arc from *S* to the line *CD*. Find the middle point of this arc and draw the line *DT* through it. Then the distance *TC* is equal to the required camber of the plate, and may be laid off from *D* to *E*. Care should be taken to use the distance *TC* and not the distance *ST*, since the two are unequal, especially when the camber is large. The distance *ST* varies by an appreciable amount from the true camber.

Having found the point *E*, we now have three points on the curve, viz.: *C*, *D* and *E*. To get additional points on the curve divide the distance *DE* by 16, and multiply the result respectively by 7, 12 and 15. Then divide the lines *CD* and *AB* into eight equal parts, and draw dotted radial lines to these points. Then along these lines, below the line *CD*, lay off the three distances just computed. Through these points a smooth curve can be drawn, and then the true length of this edge of the plate, which was found to be 31.416, may be measured off along it. This will bring the ends of the plate in towards the center *E* a slight amount, since the length of the curve measured from *C* to *D* is slightly longer than 31.416.

The development of the upper edge of the plate may be found by setting the trams to the width of the sheet 12.04, and laying off this distance along the dotted radial lines from the lower edge of the plate. Draw a smooth curve through these points and make its length equal to the length of the top edge of the plate 25.14.

In Fig. 34 a second method of laying out a tapered sheet is shown. The Fig. *ABDC* corresponds to the diagram *ABDC*, Fig. 33. Square up the line *EF* at the middle point of the line *CD*. Then locate any point as the point 1, equidistant from the lines *EF* and *BD*. This may be done by drawing a line parallel to *EF* at a distance from *EF* less than half *EC*, and then by drawing a line parallel to *BD* at the same distance from *BD*. The point where these two lines intersect is, of course, equidistant from the lines *EF* and *BD*. This is shown by the circle which has been drawn from 1 as a center, and which is tangent to both of these lines. With 1 as a center, set the trams to the distance 1*D*, and strike an arc intersecting the line *EF* at *E*; also with 1 as a center, set the trams to the distance 1*B* and strike an arc intersecting *EF* at the point *F*. The point *E* is one point in the curve of the lower edge of the plate, and similarly the point *F* is one point in the curve of the upper edge of the plate.

It will be necessary to locate several other points in the curve in order to determine it exactly. To do this, divide the lines *AB* and *CD* into eight equal parts, and through the points of division draw radial lines. Only those to the left of *EF* have been shown in Fig. 34. Then in the manner previously described for finding the point 1, determine the points 2, 3, 4 and 5, each of which is equidistant from the two sides of the respective figure in which it is located. Then, beginning with the point 5, set the trams to the distance 5*C*, and with 5 as a center strike an arc intersecting the first dotted line; also set the trams to the distance 5*A*, and with 5 as a center, strike an arc intersecting the dotted line for the upper edge. Then with 4 as a center, setting the trams to the distance from 4 to the intersection of the arcs just drawn with the first dotted line, strike the arcs intersecting the second dotted line, and re-

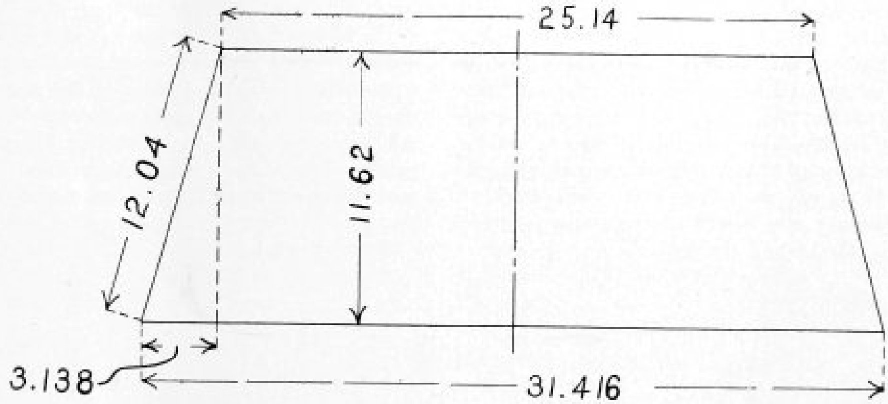


FIG. 32.

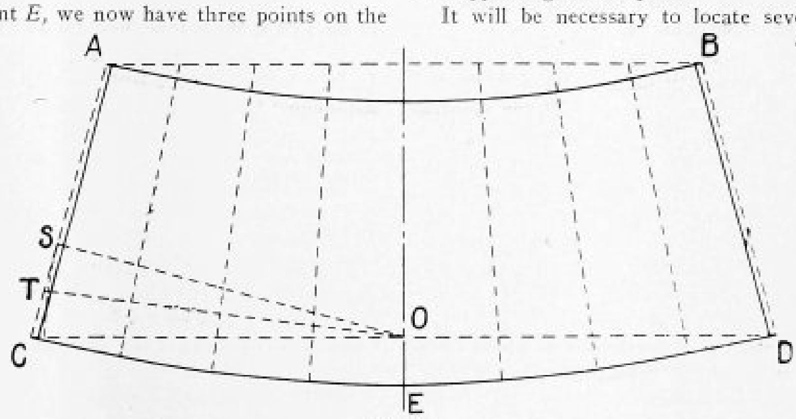


FIG. 33.

peat this process for the points 3 and 2. Then the curve, which is the true development of the edge of the plate, may be drawn through these points. The points 2, 3, 4 and 5 may be taken anywhere within their respective figures so long as they are equidistant from the sides of the figure.

With the second method just described, it is unnecessary to compute the dimensions shown in Fig. 32 and draw the diagram *ABDC*, Fig. 34, since the curve may just as well be drawn on Fig. 31 at once. In this case the side elevation, Fig. 31, should be considered in the same way as the diagram *ABDC*, Fig. 34. The curves, which are constructed to replace the upper and lower edges, will, however, be too short for the entire development of the plate. The curves may be continued beyond the side elevation, Fig. 31, by constructing on either side other figures exactly like the side elevation of the frustum. If one such figure is constructed on each side, the curve will then be increased just three times, which is nearly the required length, since the length of the curve is 3.1416 times the diameter of the base of the cone.

possibly be made dangerous, but if the water used is absolutely pure there is no chance for protection from this source.

So much is said and written about impurities in water used to feed steam boilers, that it hardly seems possible for pure water to be objectionable in any case, yet it sometimes does harm.

In the writer's plant a very large proportion of water used has been distilled in the process of heating buildings with steam that is condensed and returned to the boiler in a pure state, thus leaving the shell clean, also the tubes. The latter showed bad effects from the use of this water, more than the former. Small blisters appeared on them, and when they were removed it showed bad spots in the iron that were not there when new, but slowly came and enlarged as time passed.

Nothing was done to counteract this evil but to put three quarts of soda ash in each boiler about once a month. This caused the entire surface to become coated with a thin scale that prevents the objectionable action above mentioned.

Water used for boiler feeding usually contains more impurities than are wanted, hence strong efforts are made to dispose of them before they damage the shell and tubes.

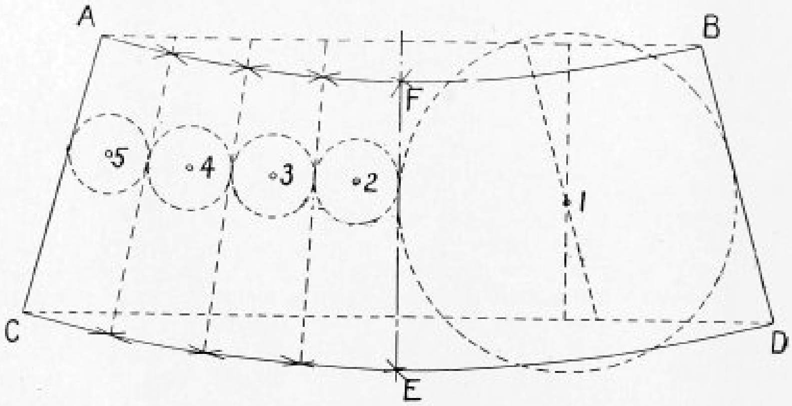


FIG. 34.

Grooving, Pitting and Corrosion in Steam Boilers.

BY W. H. WAKEMAN.

It is not difficult to understand how a machine that runs rapidly is soon worn out unless well taken care of, but when any part of a plant is absolutely stationary, as for illustration, a steam boiler, it is often difficult for the owner of such a boiler, or the public at large, to understand how it can wear out and become much weaker than it was when new. It is the object of this article to make this point clear to the non-technical reader, especially to those who own steam boilers.

We will first assume ideal conditions consisting of a perfectly clean boiler fed with distilled water containing no impurities.

When a cotton loom or any other machine is in active operation we readily understand that friction causes the parts to wear, and if we study the operation of a steam boiler it will soon be plain that while the boiler itself is motionless, the water in it travels very fast, and the speed of it is greatest in the most efficient types.

There is an old saying to the effect that "Gentle waves wear the solid rock" which may be adapted to the case we are considering without a very great stretch of imagination, for when heat enters a portion of the water in a steam boiler, it becomes lighter than before, therefore it quickly rises to the highest point possible. This tends to leave a vacant space in the boiler, but inasmuch as "Nature abhors a vacuum," other water rushes into this space and as this process is repeated indefinitely, or as long as heat is applied to the water, the action slowly wears the plate of which the boiler shell is constructed, and this is called grooving.

From the above description it will be plain if the shell is protected from this action it will not become worn thin and

One plan for doing this is to remove foreign matter before feeding water into the boiler, and this process is called "water softening," because water that will not readily mix with soap and form lather is always called "hard," hence pure water is termed "soft." Water-softening plants are in successful operation in many parts of the country, under different conditions, but the first cost of them is rather heavy. However they prove to be profitable, especially for large plants.

Another plan for preserving steam boilers where the water is naturally bad, is to introduce suitable compounds to neutralize the bad effects of the foreign matter in it. While this is a constant expense it is not excessive and a special plant is not necessary.

While the foreign matter found in different parts of the country differs widely, a certain compound will sometimes answer for several places, but the only safe way is to have the feed-water analyzed by a competent and reliable chemist, who will prescribe a remedy that will be good for that case.

While we are not prone to think that nearly everybody is dishonest we are willing to say that none but parties known to be honest should be entrusted with this important work.

Treatment of boiler feed-water is sometimes based on analysis of the scale which forms on the inside of a boiler. This seems rational because this scale contains much that informs a chemist of the true condition of the feed-water. It is not a difficult matter to procure a few cheap drugs and concoct a compound that will do good work in removing old scale from a certain boiler, but when such a compound is advertised as a universal panacea for the ills and abuse from which boilers under all conditions are suffering, we are incredulous.

If a boiler is badly scaled it is dangerous to put a large quantity of compound into it, then use it for a month, without internal inspection. A large body of scale may be thrown down, and, forming into a solid mass, prevent water from coming in contact with the iron or steel composing the shell and causing it to be burned.

Strange as it may seem, a compound is not always given credit for doing good work along this line, even when it is clear to all concerned that it has accomplished exactly what it was intended to.

There are boilers in use that would be full of holes if their internal surfaces were not coated with scale, consequently when a compound is introduced that removes this scale the boiler leaks. This appears only natural, but when an engineer or a steam user says that he will use no more of that compound because it made his boiler leak, it plainly becomes one of those half truths which are more dangerous than a simon pure misstatement.

Such a condition of affairs is possible because a new boiler has a large factor of safety, therefore as it grows old and the parts become weaker the margin of safety is reduced until in some cases it disappears and the result is a boiler explosion of more or less violence.

Soda ash has already been mentioned as a remedy for certain troubles, but like many other good things it is quite possible to use too much of it, thus creating a worse condition of affairs than existed before a remedy was attempted. After such a warning the reader naturally wants to know how much to use, and if it was possible to state arbitrarily just how much to put in a boiler it would give me pleasure to do it, but unfortunately this cannot be done. The amount necessary will depend on the size of boiler, pressure carried, amount of water evaporated, and what impurities are found in the water.

If three or four quarts are put into a boiler that can easily develop 100 H. P., it will not be too much and if another quart is added each day for a week, it will probably do no harm. When a white substance begins to show around valve stems, flange joints and water-gage connections it indicates that the water is saturated with the soda ash, and its use should be discontinued for a time. A few experiments will enable the engineer to determine the proper amount to use in his particular case.

Manufacturers of boiler compounds sometimes object to the mention of soda ash, as it injures their business, and the writer remembers an instance of this kind very plainly, where the dealer's indignation was very marked, but we are quite sure that a very large proportion of ordinary compounds consists of soda ash, with a few other ingredients, some of which are intended to disguise the soda ash and lend dignity to the whole concern.

The excessive use of soda ash has a bad effect on the packing used in flange joints, causing it to lose its strength, after which it is blown out by the steam pressure, making much disagreeable work in replacing it.

Too much soda ash will cause foaming or violent agitation of the water, and some of it is thrown into the steam space whence it passes to the engine where it prevents the cylinder oil from lubricating the sliding surfaces as it otherwise would. In an effort to remedy this evil, the engineer feeds in more cylinder oil, which does not wholly eliminate the cause of trouble, but on the other hand it may complicate matters more and more.

In a steam heating system where the condensed steam is returned to the boilers, it is necessary that all of the cylinder oil be removed, unless it is almost pure mineral oil, for if there is over 2 percent of ordinary tallow, which always contains more or less acid, it is dangerous. If this is fed into a steam boiler it forms into a sticky, tenacious mass that floats on the surface at first, but after it has collected particles of foreign matter that are floating around, it becomes heavier than the hot water, hence sinks to the lowest points where it cleaves to the metal surfaces and effectually prevents water from reaching them.

An immense quantity of heat is constantly passing through the plates in a boiler and is carried off by the water, but when an obstruction of this kind prevents the rapid removal of this heat, it must of course accumulate in the plate. Iron increases in strength as its temperature rises, until it reaches about 550 degrees F., after which it begins to weaken, and when a dull red is attained its strength is greatly impaired, hence it cannot maintain its form, but bulges out and forms a bag. The intense heat then drives the objectionable matter away, so that when the manhole cover is removed for inspection there is little or no trace of oil left.

Corrosion or the wasting away of the iron composing a steam boiler may be due to acid in the feed-water. Where sulphuric acid is found in this water its destructive force is sometimes partly or wholly spent in destroying the feed pipes before it actually enters the boiler. This is expensive, annoying and even dangerous in some cases, but is much preferable to a boiler explosion.

Galvanic action sometimes weakens steam boilers, and as this is a very interesting feature it will be explained. Water is distilled in a steam boiler, therefore it is broken up into its constituent parts, namely, two parts of hydrogen and one of oxygen.

The parts of a steam boiler are made of particles or molecules of iron, silicon and carbon compounds, and the rapid transmission of heat through them causes molecular action, which in turn creates friction between the molecules, resulting in the production of a galvanic electric current.

Galvanic action signifies the transmission of an electric current from one body to another, and in the process the positive pole, or in other words, the part that receives the current first and sends it to another is destroyed first.

In a boiler made of iron with brass trimmings, the iron becomes the positive pole, and in this connection it is well to remember that brass is composed of copper, zinc and tin, and some of it may contain about 85 percent of copper, thus doing good work as a conductor of electricity. This explains why boiler inspectors are not very enthusiastic in recommending brass feed pipes and water-column connections.—*The Tradesman.*

Arithmetic of Boiler Stays.

BY CHARLES J. MASON.

One of the things upon which the embryo engineer must post himself in order to obtain a certificate of competency, is the calculations pertaining to boiler stays, and while there are many rules in existence relating to the subject as found in various text-books, it is difficult to discover any close relationship between them, unless the seeker has had previous experience in such work and knows how to select just the rule he requires for a certain problem; and also how to logically group the different rules so as to be applicable to any problem which may arise. When a student understands the different cases, and what rule to apply to each, it may be said that he has all that is required—for the mere arithmetical operations are simple and easily learned, if the student does not know them already. Now, the object of this article is to try to present to the reader as briefly as possible consistent with clearness, all that pertains to calculations concerning stays.

We will assume that the reader knows what boiler stays are, how they are made, and what they are for. Nearly everyone in the engineer's department of a steam vessel knows these things, but comparatively few know how to make the necessary calculations relating thereto, so we will confine ourselves to the latter, simply referring to the former when occasion requires.

The size of a boiler stay depends upon: how many there are in a given area of surface to be stayed, or in other words, what distance apart the stays are; upon the pressure per square inch to be carried in the boiler; and also upon the tensile stress per square inch allowed on the stay.

The distance apart that stays should be spaced depends upon the size of the stays and the pressure per square inch to be carried. In marine boilers, stays are spaced sufficiently far apart to admit of a man entering the boiler and making a thorough examination of the internal surfaces.

Assuming the stays to be spaced equally, as they should be as far as possible, the area of plate supported by one stay is found by squaring the distance between centers of stays. For example, suppose in a given boiler the distance from center to center of stays is 16 inches, then each stay supports $16 \times 16 = 256$ square inches of plate surface. The steam pressure is not effective on that portion of the area so found, which is occupied by the stay itself, although if it were included in the calculation the result so obtained would be on the safe side, as can be seen after a little thought has been given to the subject.

The area, in square inches, supported by one stay, multiplied by the pressure per square inch carried, will give the total stress endured by the stay. As there is a certain allowable stress per square inch, it will be seen that in determining the size of stays this must be considered.

So far we have said nothing about the thickness of the plate to be stayed. When the stays in boiler heads are properly spaced, it is presumed that the head or tube sheet is sufficiently thick and proportionately strong enough to stay itself between the stays, so in this case the thickness of plate does not enter into the calculation. But in the case of stay-bolts bracing comparatively thin plates, then the thickness of the plate enters into the calculation and formulas are in use for just such cases.

In this article we will deal with through stay-rods and stay-bolts and diagonal stays.

The formulas employed for through stays may be grouped as follows, so that the student-reader may see at a glance what he has to deal with as a whole, and just which one of the formulas he will require in order to operate any given problem.

FORMULA ONE.

If it is required to find what should be the diameter of stays for a given boiler, the data given to operate the problem will be: the area held by one stay (which is found by squaring the distance apart, center to center of stays), the pounds pressure per square inch to be carried, and the allowable tensile strength of the stays, per square inch section. The statement of the formula is like this:

$$\frac{\text{Area held by one stay} \times \text{pounds pressure per square inch}}{\text{Tensile strength allowed}} =$$

area of stay in square inches, from which the diameter in inches may be found by dividing the area by the constant .7854 and then extracting the square root of the quotient.

The reader should have no difficulty in understanding this latter process, when he considers how the area of a circle is found, for the process is simply reversed, as will be seen. With regard to the extraction of the square root part of the operation, we would wish that every marine engineer be able to do both square and cube root. If difficulty is met with in these operations, then the reader must refer to a table of square and cube roots which are contained in most engineers' handbooks. Let me also add, that no engineer should be without a copy of *Kent's Mechanical Engineer's Pocket Book*, or other equally reliable authority, for such a work is frequently required as a reference.

FORMULA TWO.

The second formula in the group is to find the area of the stayed part, or in other words, the area of plate supported by one stay, from which may be found the distance apart the stays must be. The statement appears like this:

$$\frac{\text{Area of one stay} \times \text{the allowable tensile strength}}{\text{Pressure per square inch}} =$$

area held by one stay. Extract the square root to find the distance apart the stays must be.

FORMULA THREE.

The third formula is seldom ever used, but as it is part of the system it is given to complete the group, and so serve the useful purpose of showing the construction of the formulas, and just how the different factors are related to one another.

It is to find the allowable tensile strength of the stays. This is the statement:

$$\frac{\text{Area supported by one stay} \times \text{pressure per square inch}}{\text{Area of one stay}} =$$

allowable tensile strength per square inch section.

FORMULA FOUR.

The fourth is to find the pressure per square inch which may be carried in the boiler:

$$\frac{\text{Area of one stay} \times \text{tensile strength per square inch section}}{\text{Area supported by one stay}} =$$

pressure per square inch which may be carried.

The following rules apply where the plates to be stayed are over 7-16 inch thick. The stress per square inch allowed is 6,000 pounds, for stays up to and including 1¼ inches diameter. Steel stay-bolts exceeding 1¼ inches diameter and not exceeding 2½ inches diameter at the bottom of the thread, are allowed a stress of 8,000 pounds per square inch of cross-section. Steel stay-bolts exceeding 2½ inches diameter at the bottom of the thread are allowed a stress of 9,000 pounds per square inch of cross-section.

UNITED STATES GOVERNMENT RULES.

When flat surfaces are to be stayed, the plates of which are 7-16 inch or less, the United States Government rules are as follows:

(1) To find the allowable steam pressure per square inch:

Multiply the constant whole number 112 by the square of the thickness of plate, in sixteenths of an inch, and divide the product by the square of the distance from center to center of stay-bolts in inches; the quotient will be the safe working pressure. This expressed in a formula appears like this:

$$P = \frac{112\, t^2}{D^2}$$

In which $P =$ safe working pressure per square inch; 112 is a constant for plates not over 7-16 inch thick. (When the plates are over 7-16 of an inch thick the constant 120 is used instead of 11.) $t =$ thickness of plate in sixteenths of an inch; and $D =$ distance from center to center of stay-bolts.

The attention of the reader is called to the fact that in the operation of the rule just given, the "sixteenths of an inch thickness of plates" referred to is to be considered as a whole number, not as a fraction, as at first it might seem. For example, if a plate of 5-16 inch is considered, then in the operation, t^2 would be written $5^2 = 25$, not $5\text{-}16^2$. It simply means to use the numeral which represents the number of sixteenths of an inch thickness of the plates.

(2) Under the same heading, to find the pitch of stay-bolts, the following formula applies:

$$S = \sqrt{\frac{112\,t^2}{P}}$$

In which S = pitch of stays in inches, and the other letters and constant the same as in the preceding formula. As before, if the plates are more than 7-16 inch thick the constant 120 is to be used instead of 112. Both of these constants have been made choice of because of the satisfactory results attained by their use.

(3) When it is desired to determine what thickness of plates should be used, when the steam pressure and the pitch of the stays are given, the formula becomes:

$$t = S\sqrt{\frac{P}{112}}$$

If this formula gives t a value of more than 7-16 inch, use the constant 120 instead of 112. The value of the letters are the same as before.

(4) To find what distance the stays should be apart from center to center, the formula becomes:

$$A = \frac{112\,t^2}{P}$$

for plates up to 7-16 inch thick.

$$A = \frac{120\,t^2}{P}$$

for plates above 7-16 inch thick.

And, when screw stay-bolts and nuts are used, this formula is used:

$$A = \frac{140\,t^2}{P}$$

In these formulas A = area of stayed part, from which the pitch may be found by extracting the square root. The value of the other letters are the same as in the preceding formulas.

The diameter of diagonal stays requires to be somewhat larger than that of through (or direct) stays, because of the angle which the stay makes with the surface it stays. The following formulæ will make clear what is contained in the rules relating to this part of the subject:

First, ascertain the area of a direct stay required to support the given surface, according to the formula before given. Multiply the area so found by L, which is the length of the diagonal stay. Then divide the product by the distance A along the shell from the head to the end of the brace. The quotient will be the area of the diagonal stay.

The diameter may be found as before explained.

DIAGONAL STAYS.

The formulas for diagonal stays may be grouped as follows (all dimensions to be made in inches):

(1) $\dfrac{\text{Area of direct stay} \times L \text{ (length of diagonal stay)}}{A \text{ (refer to diagram)}} =$ area of diagonal stay.

$$\sqrt{\frac{\text{Area}}{.7854}} = \text{diameter of stay.}$$

(2) $\dfrac{\text{Area of diagonal stay} \times A}{\text{Area of direct stay}} =$ L (length of diagonal stay).

(3) $\dfrac{\text{Area of diagonal stay} \times A}{\text{L}} =$ relative area of direct stay.

(4) $\dfrac{\text{Area of direct stay} \times L}{\text{area of diagonal stay.}} = A$

(5) $\dfrac{L}{A} \times$ area supported by one stay $\times$ pressure per square inch = load in pounds supported by one stay.

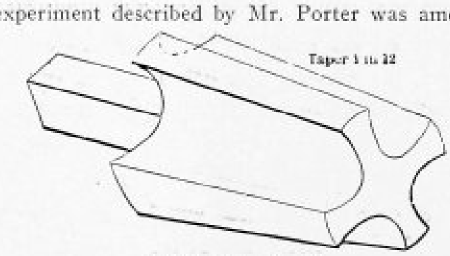
Time and space forbid an attempt to illustrate all of the foregoing formulas by substituting numerals in place of the letters and phrases, but the interested reader may do so himself, and thus demonstrate the value of the formulas; for in any one group each formula when applied to a given set of figures will prove the correctness of the others. Working out a set of examples by these formulas should prove very interesting, and at the same time instructive.—*The American Marine Engineer.*

Relative Efficiency of Boiler Tubes.

Perhaps some of our readers will remember a short article descriptive of a method for finding the difference in temperature in the flues of a return tubular boiler, published on page 47 of our February, 1907, issue. Mr. A. L. Haas, in a current issue of the "American Machinist" tells of a similar experiment told to him by the chief engineer of a steamship who had carried it out.

The boilers were well up to their work, but after ascertaining the consumption of coal per horsepower-hour, he came to the conclusion that it was too high. As the boat was new and he desired to please the powers that were, he tried several expedients.

The experiment described by Mr. Porter was among them.



BOILER-TUBE PLUG

As a practical man the engineer was struck by the disproportion of value existing between tube and tube. Plotting the results obtained, he informed me that the arrangements of the more efficient tubes suggested a truncated triangle. Not content with simply obtaining these results he adopted a remedy, which was to partly stop the tubes carrying the most heat at the front or smoke-box end. To do this he had a number of tube plugs cast as shown in the sketch. He inserted these plugs in the tubes, and by securing a better distribution of heat obtained an increased economy.

Experience has shown me that with some boilers a gain in economy is marked after a day or two's steaming, when some tubes are partly choked. To check this fact entails considerable labor, in weighing coal out for use several times on a run and taking cards at the time the weighed coal is used.

The distribution of the tubes to increase their effectiveness would seem to be a question that can only be settled by scientific experiment; and a clear case for experiments of this character by one of the technical schools is made out, and the results obtained should be of value.

PERSONAL.

Mr. H. S. Jeffery, of Brantford, Ontario, Can., has accepted a position as the head of a course for boiler makers with the International Correspondence Schools of Scranton, Pa. Mr. Jeffery expects to leave Brantford the 1st of June.

Mr. Thomas F. Aldcorn, of the Chicago Pneumatic Tool Company, of Chicago, Ill., has just returned from the Atlantic Coast, where he has been closing up the yearly contracts of this company in the shipyards.

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - New York

Christopher St., Finsbury Square, London, E. C.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico........	$1.00	.10
Other countries in Postal Union..........	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

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 5,800 *copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.*

For the Master Boiler Makers.

On another page of this issue will be found the proposed program for the joint convention of the International Railway Master Boiler Makers' Association and the Master Steam Boiler Makers' Association, which is to be held at the Hollenden Hotel, Cleveland, Ohio, on May 21, 22 and 23. This program has been most carefully arranged, and the details of carrying it out have been submitted to competent committees, so that the master boiler makers of both associations may be assured that when they come to Cleveland in May they will not only be entertained in a royal manner but will have something of interest to discuss and work of importance to do.

Each association is to present two topics before the convention for discussion, and very complete and comprehensive papers are being prepared on these subjects. Due to the unusual amount of business which will necesarily arise from the consolidation of the two associations, it has been found necessary to limit the number of such papers.

The success of the convention this year depends upon the attitude and enthusiasm of the individual members, since it is the first time that the two associations have ever met together. Therefore, each and every member should plan to attend and contribute something to the success of this undertaking. The way has been paved for success and now it is up to the master boiler makers to carry this program through, so that the results of this meeting will be felt in the trade. Considerable interest has already been shown by boiler makers who do not belong to either association, so that there will undoubtedly be a large number of new members admitted to the joint association.

The Champion Prizes.

We wish to call the attention of our readers again this month to the offer of three prizes of $50.00, $35.00 and $25.00, made by Mr. David J. Champion, for the best articles on "How to Heat and Drive Steel Rivets." The conditions of this contest, which were announced last month, are: That each paper shall consider the best method of heating rivets; that is, the most desirable fuel to be used and the degree of heat most desirable for different methods of driving the rivets, and the different methods and tools used in driving rivets, viz.: hydraulic-driven rivets, pneumatic-driven rivets, and hand-driven rivets.

All papers written in competition for these prizes must be in our hands not later than 12 o'clock on Wednesday, the first day of May. The papers should be left unsigned except by an identifying mark, which should be sent to us separately in a sealed envelope bearing the writer's name and address. These papers will then be submitted to the committee which has been chosen for awarding the prizes, and the results of the contest will be announced at the Master Boiler Makers' convention at Cleveland in May.

Remember that this contest will be closed before our next issue has reached you, and therefore all papers written in competition for these prizes should be sent to us promptly.

Rolling Boiler Plate.

An observation on the behavior of boiler plate when being rolled has recently been published by one of our contemporaries, stating that when a plate is formed into the shape of a boiler shell, it does not bend on its center line or nominal neutral axis. It states, further, that a boiler maker always takes the measure of a straight sheet for a certain outside girth, and makes little or no allowance for change of length due to bending. When the sheet is in the bending rolls, it will be noted that practically all the scale cracks loose from the interior of the shell and very little drops off the exterior, and that the sheet as a whole is thickened slightly. It is claimed that this action is due to the fact that the outside fibers do not have an opportunity to stretch, since the plate is so wide that it prohibits the possibility of the sheet narrowing throughout its width in order to compensate for this stretching; consequently the sheet does not change its cross-section materially except to become slightly thicker, thus shortening the interior fibers.

When the plate or bar is bent, before the stress in the material reaches the elastic limit, the plate will bend on its center line as the neutral axis, but when the plate is bent sufficiently to retain permanent curvature or set, the stress in the material has exceeded the elastic limit and the neutral axis of the plate cannot be said to be at the center of the thickness of the plate. It is common practice, however, for boiler makers to lay off the plates which are to be rolled into a boiler shell to measurements taken at the center of the thickness of the iron, making such small allowances as experience has shown necessary to obtain a fit. It might safely be stated that this procedure is almost universal, and since the plates laid out in this way are found to roll to the desired size, it seems reasonable to suppose that the neutral axis about which the plate is bent does not vary far from the center of the thickness of the plate.

TECHNICAL PUBLICATIONS.

"Railroad Pocketbook." By Fred. H. Colvin. Size, 6 by 4 inches. Pages, 217. Illustrations, 125. Derry-Collard Company, New York. Price in flexible covers, $1.00.

This hand-book contains in condensed form a great amount of information about all matters pertaining to the different branches of railroad work, including the motive power, maintenance of way and rolling stock. The subjects are arranged alphabetically, and the articles are thoroughly cross referenced, so that any information in the book may be readily found without the trouble of using an index. The data given is brought up to date, and has been obtained from thoroughly reliable sources.

Considerable matter which is of interest to boiler makers is contained in the book, since not only are the different types of locomotive boilers illustrated and described, but also information is given in a convenient form regarding the calculations which pertain to the design and strength of such a boiler.

"Henley's Twenty Century Book of Receipts, Formulas and Processes." By Gardner D. Hiscox, M. E. Size 9 by 6 inches. Pages, 787. Illustrations, 25. The Norman W. Henley Publishing Company, New York. Price, cloth bound, $3.00.

In compiling this book of formulas the author has endeavored to meet primarily the practical requirements of the mechanic, manufacturer, artisan and housewife. About 10,000 different formulas have been collected, which cover a very wide field and present a ready means of finding specific information for use in making or repairing the thousand and one things which enter into our complex daily life. Only those receipts which can be used by one not thoroughly conversant with the subject in hand have been selected, in order to make the book more general.

The formulas are arranged in alphabetical order and the text is thoroughly interspersed with cross references, so that information pertaining to a particular subject may be easily found. Illustrations have been used in the description of several processes of manufacture where necessary in order to give a clearer idea of the method.

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 accompanied by the name and address of the writer.

Q.—How do you get the pressure on a stay-bolt in a stationary boiler? H. L.

A.—If P = the working steam pressure in pounds per square inch.

d = the smallest diameter of the stay-bolt measured at the root of the thread.

p = the pitch of bolts.

f = the stress in stay-bolt in pounds per square inch.

Then $f = P \times \frac{4p^2}{3.1416\ d^2}$

The above formula gives a means of calculating the stress on the bolt when the working pressure on the boiler and the pitch and diameter of bolts are given. This formula is obtained as follows

It will be noted from the accompanying diagram that where stay-bolts are spaced regularly, each bolt must stay a portion of the surface, as indicated by the dotted square, the length of whose side is p, the pitch of the bolts. The area to be supported is, therefore, p^2. The pressure on this surface will be p^2 times the working pressure in pounds per square inch, or $P \times p^2$. This is the total pressure on one bolt.

This pressure must be supported by the bolt whose cross-

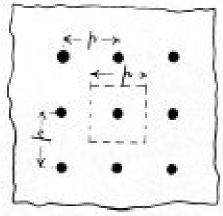


DIAGRAM SHOWING AREA SUPPORTED BY ONE BOLT.

section is a circle with a diameter d. Its area, therefore, is $\frac{3.1416\ d^2}{4}$. This area times the fiber stress in the bolt, must be equal to $P \times p^2$. Therefore,

$$f \times \frac{3.1416\ d^2}{4} = P \times p^2 \text{ and } f = P \times \frac{4p^2}{3.1416\ d^2}$$

The pitch and diameter of the bolts for a given working pressure should be so proportioned that f will be never larger than about 6,000 or 9,000 pounds per square inch.

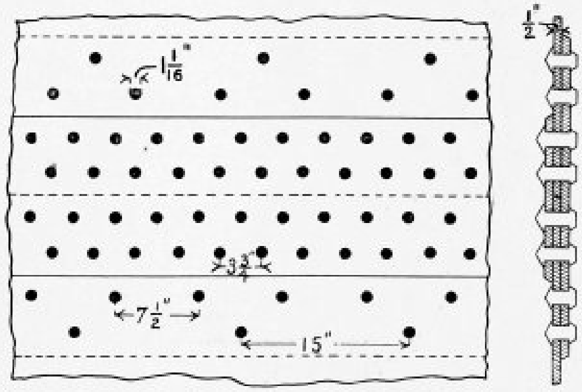
The United States rules for marine boilers state that f shall not exceed 6,000 pounds per square inch.

The British Board of Trade rules give f as 9,000 pounds.

The British Lloyds give 8,000 pounds if the stay is under 1½ inches in diameter and 9,000 pounds if over 1½ inches in diameter.

German Lloyds give 1/7 of the tensile strength.

The Hartford Steam Boiler Inspection & Insurance Company have no official rule, but recommend that f shall not be greater than 7,500 pounds per square inch on long stays or 4,800 pounds per square inch on short stays.



QUADRUPLE RIVETED BUTT JOINT.

Q.—Will some of the readers of THE BOILER MAKER show how to figure the double butt strapped joint shown in the accompanying sketch? The plate is ½ inch in thickness, and the rivets are 1 1-16 inches in diameter when driven. The two inner rows of rivets, which are in double shear, are spaced 3¼ inches between centers, while the two outer rows, which are in single shear, are spaced 7½ and 15 inches, respectively, as shown in the sketch. E. P.

The MacKinnon Boiler & Machine Company, Bay City, Mich., report the addition to their foundry of a 48-inch shell cupola. They are also increasing the height of their 60-inch shell cupola.

ENGINEERING SPECIALTIES.

A New Rotary Air Compressor.

The accompanying cuts show a new type of air compressor which has recently been placed on the market by the Roteng Engineering Corporation, 299 Broadway, New York City. This machine differs from the ordinary types in the arrangement of its cylinders which radiate from a single shaft. The entire machine is enclosed in a case, giving it the appearance of an electric generator.

The cylinders are of cast iron completely water jacketed. They are single acting and radiate from a hollow steel shaft on which the cylinder casting is secured. Each cylinder has a single port at its inner end communicating with the interior of the shaft. These ports are large in proportion to the cylinder capacity, allowing them a large intake volume without wire drawing.

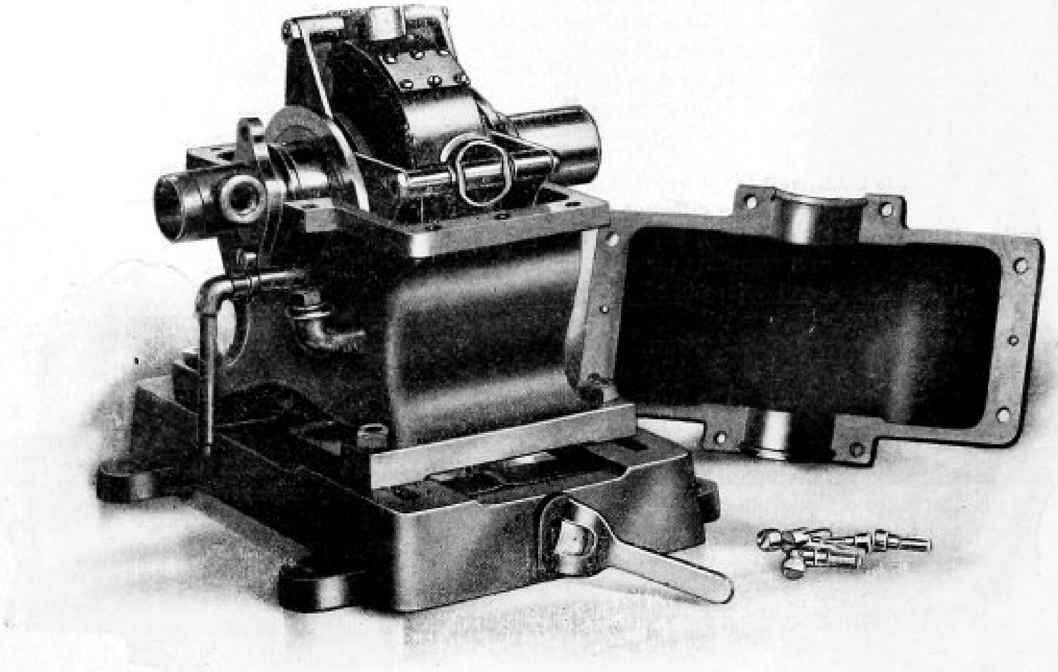


FIG. 1.—VIEW OF THE ROTARY COMPRESSOR WITH TOP OF CASE REMOVED.

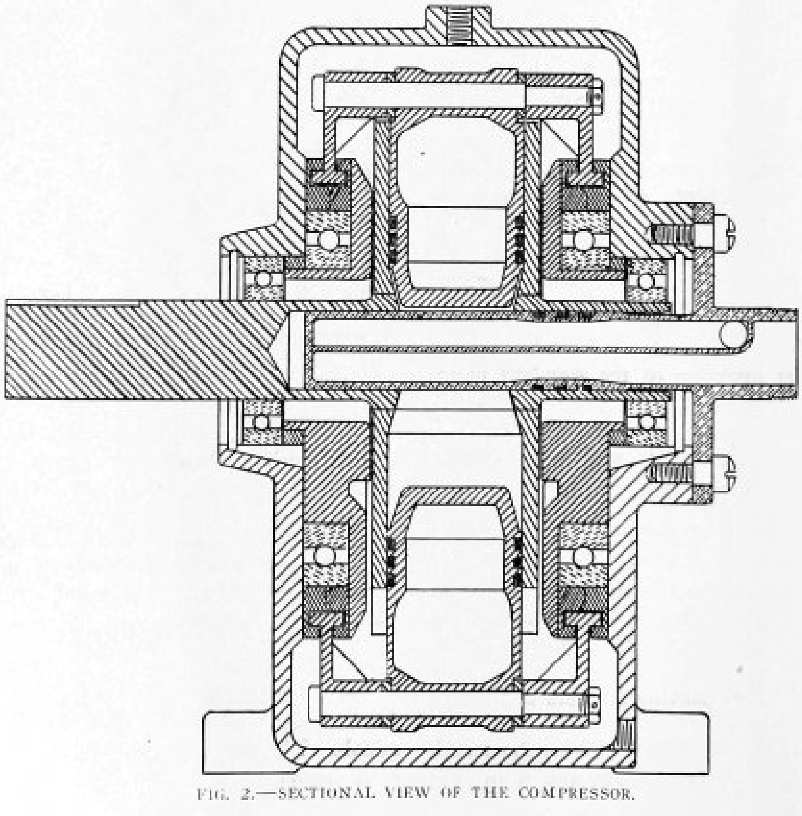


FIG. 2.—SECTIONAL VIEW OF THE COMPRESSOR.

The pistons are cast hollow in order to reduce their weight, and are packed with ordinary cast iron snap rings. Projections on the inner ends of the pistons fill the ports completely, thus reducing the clearance space to a minimum. The pistons are suspended at their outer ends by wrist pins in independent yokes, which revolve in a bearing eccentric to the shaft bearing on which the cylinder turns. The main bearings are of the ball type, a construction which is made possible by the fact that they are not subjected to any sudden strains or shocks. It is claimed that all motions and strains are steady and uniform.

The inside of the hollow shaft forms the valve seat. The valve is of bronze, and is divided into intake and exhaust chambers by a partition. Each chamber has a port at its inner end and a pipe connection at its outer end. The valve is anchored to the case so that as the shaft revolves around it the cylinder ports pass over the valve intake chamber port during the outward motion of the piston in the cylinder. At the extreme end of the out-stroke the intake is cut off, and as the piston is forced back into the cylinder the air is compressed to approximately the reservoir pressure wanted, when the cylinder port passes over the discharge port in the valve through which all air in the cylinder is expelled. The different periods of admission, compression and discharge are automatically accomplished by the revolution of the shaft

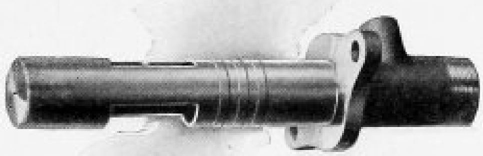


FIG. 3.—VALVE REMOVED FROM THE SHAFT.

around the valve. The valve automatically seats itself because of the pressure on the discharge side forcing it against the intake port. Longitudinal leakages are prevented by snap rings running in grooves around the valves.

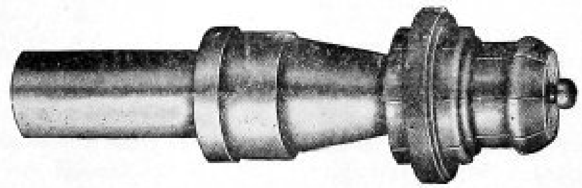
Owing to the light weight and perfect balance of these machines, no special foundation is required. The machines may be arranged for either belt drive, motor drive or gas or steam engine drive. In the case of belt drive an adjustment is provided in the base for taking up the tension of the belt without stopping the machine.

The machines are now being built in capacities ranging from 1 cubic foot of free air per minute to 150 cubic feet. Portable motor-driven machines up to 50 cubic feet in capacity, ranging from 450 pounds complete for the 15-foot to 1,200 pounds for the 50-foot, which will carry pressures up to 100 pounds per square inch, are especially adapted for all kinds of outside work where pneumatic tools are used, such as the erection of boilers, stacks, tanks, etc.

The Lucas Pneumatic Sectional Spring Tube Expander.

The accompanying cut shows the new power spring expander, which is being manufactured and sold by W. H. Dangel & Co., 140 Dearborn street, Chicago, Ill. This tool is the invention of Mr. D. A. Lucas, foreman boiler maker of the B. & M. R. R. R., at Havelock, Neb., and it has been designed for the purpose of expanding flues rapidly without injury to the tube sheet. It has the same general contour as the Prosser type of spring expanders, but the taper of the pin or mandril is much greater, in order to prevent any sticking in the sections.

The expander is operated by a small size pneumatic hammer (a No. 5 or No. 6), since there is no necessity for using heavy blows. In this way the Lucas expander works the flue readily in the sheet without working the sheet, and it is claimed that the life of the flue sheet will be lengthened, since



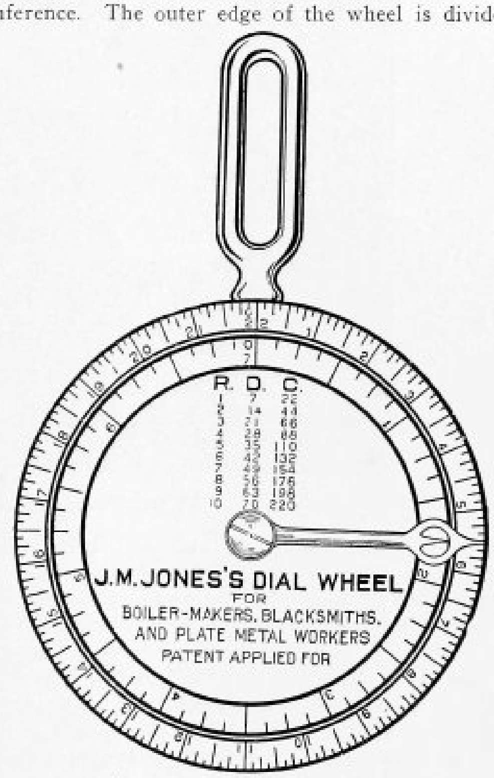
LUCAS SECTIONAL EXPANDER.

there will be fewer cracks between the bridges and less elongation in the tube holes.

The tool is made of high-grade tool steel, carefully finished and tempered, with a view to durability. The 2-inch size is only 8 inches long, over all, thus bringing the operator close up to the work and enabling him to do a rapid job.

Dial Wheel for Boiler Makers, Blacksmiths and Plate Metal Workers.

The accompanying illustration shows a new measuring wheel for layers-out and sheet metal workers, which is being placed on the market by J. M. Jones, 270 Broadway, Cambridge, Mass. The wheel is 7 inches in diameter, and, therefore, 22 inches in circumference. The outer edge of the wheel is divided into



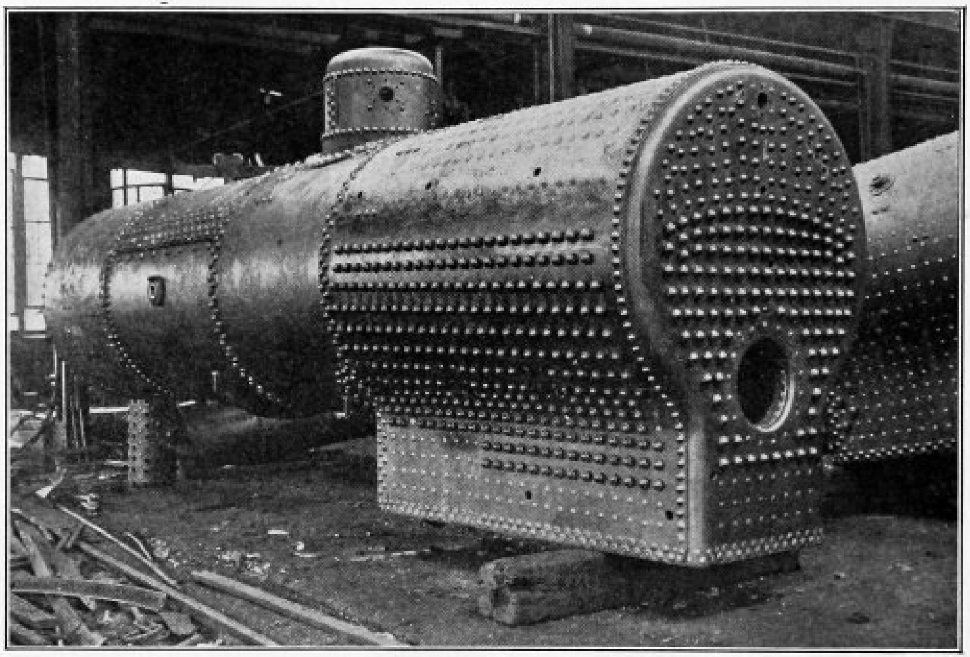
JONES' DIAL WHEEL FOR BOILER MAKERS.

inches and eighths of an inch. An inner circle is divided into seven parts, each part representing an inch in diameter. These parts are again subdivided into eighths, representing eighths of an inch in diameter. The indicator hand has two points on the same radial line, so that when the inner point is at a division on the inner circle representing the given diameter, the point at the extremity of the hand indicates the circumference corresponding to that diameter.

The letters R, D, C indicate respectively revolutions, diameters and circumferences. One revolution of the wheel rolls a circumference 22 inches in length, which corresponds to a diameter of 7 inches. Complete revolutions of the wheel measure off circumferences corresponding to diameters, which are an even multiple of seven. For diameters other than multiples of seven, the indicator hand may be set at the proper point on the inner circle, and a corresponding fraction of a revolution rolled in addition to the required number of complete revolutions of the wheel.

Tate Flexible Stay-bolt.

The high temperatures maintained in the large fire-boxes which are now in use on locomotive boilers cause a damaging amount of expansion and contraction of the fire-box sheets. When these sheets are stayed with rigid stay-bolts, there is comparatively little chance for the sheets to expand without setting up severe stresses in both the stay-bolts and the sheet. In districts where the feed water is bad, the incrustation on the sheets and bolts causes them to be heated to an even higher temperature, and, therefore, causes even greater stresses in the bolts and sheets. It is claimed by many that the fact that the fire-box is so rigidly stayed is the cause of a great number of breakages in stay-bolts. By fitting flexible stay-bolts in the breaking zone of fire-boxes, that is in the parts of the fire-box where experience has shown that bolts are most liable to fracture, the number of breakages and large expense of renewals have been decreased quite materially. The breaking zone may be considered as covering the horizontal rows of stay-bolts below the crown sheet line, six to eight in number, spreading diagonally across the corners and running downward in the first two or three rows next to the back head, flue and throat sheets and the entire surface of the throat sheet.



LOCOMOTIVE BOILER FITTED WITH TATE FLEXIBLE STAY-BOLTS.

The accompanying illustration shows a 72-inch locomotive boiler of the straight top type fitted with 697 flexible stay-bolts. The particular bolt used in this case is the "Tate" flexible stay-bolt manufactured by the Flannery Bolt Company, Pittsburg, Pa.

It will be noticed that the flexible stays are used only in the 4-inch water space, the crown sheet being supported by radial stays 1⅛ inches in diameter. The inside dimensions of the fire-box in this boiler are: Length, 96 inches; width, 32⅛ inches. The crown sheet is 7/16 inch thick; the tube sheet, ½ inch; the side and door sheets, ⅜ inch thick; while the boiler shell is ¾ inch.

Report seems to indicate that of the thousands of these bolts which are now in use on different railroads very few have been known to fail.

SELECTED BOILER PATENTS.

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

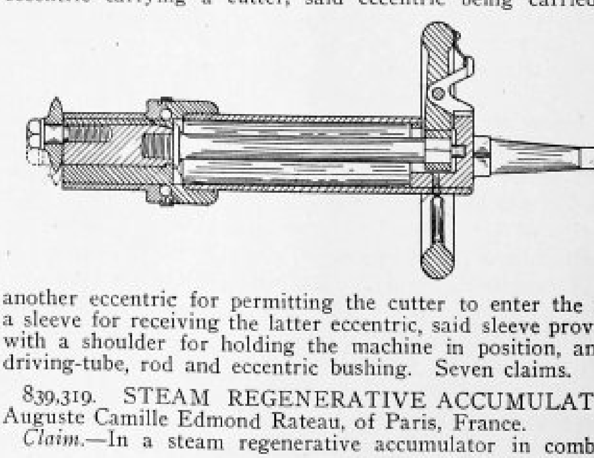
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

839,263. FURNACE. Samuel T. Bleyer, of Chicago, assignor to the Hawley Down Draft Furnace Company, of Chicago, Ill.

Claim.—In a down-draft furnace, the combination of front and rear manifolds arranged in the furnace chamber, a set of water tubes forming a grate communicating between the manifolds and dividing the chamber into an upper or fuel chamber and a lower or fire chamber, uptake pipes communicating with the front manifold, pipes or legs depending from the rear manifold, and a set of supplemental water tubes communicating between such uptake pipes and the depending pipes. Four claims.

839,135. BOILER FLUE, PIPE AND TUBE-CUTTING MACHINE. Ferdinand G. Haas, of Springfield, Mo.

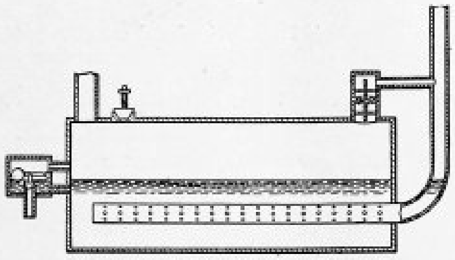
Claim.—In a flue-cutting machine, the combination of an eccentric carrying a cutter, said eccentric being carried by



another eccentric for permitting the cutter to enter the flue, a sleeve for receiving the latter eccentric, said sleeve provided with a shoulder for holding the machine in position, and a driving-tube, rod and eccentric bushing. Seven claims.

839,319. STEAM REGENERATIVE ACCUMULATOR. Auguste Camille Edmond Rateau, of Paris, France.

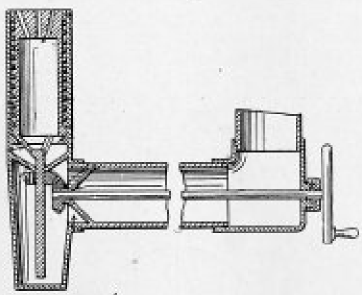
Claim.—In a steam regenerative accumulator in combination, a vessel containing liquid as a heat carrier, piping for directing steam into the liquid, a duct or opening for substantially maintaining the liquid at a given level, a steam



escape valve, said vessel having an outlet above said level for conveying steam from said vessel, a by-pass between a portion of the accumulator containing regenerated steam and said piping, and a valve in said by-pass subject to regenerated steam pressure and pressure of steam within said piping to check back flow of liquid through said piping. Twelve claims.

839,524. STEAM BOILER TUBE CLEANER. David F. Taber, of New York, N. Y.

Claim.—In a device of the character designated, the combination with the inclosing shell and means for supplying steam under pressure thereto, of a longitudinally-movable nozzle, a



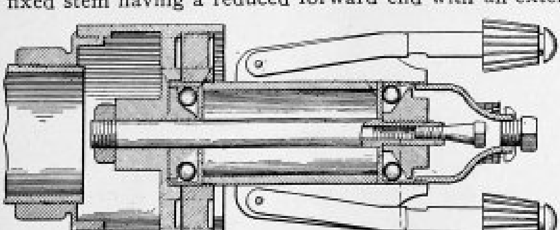
spiral spring surrounding said nozzle and interposed between it and the inclosing shell, one end of said spring resting against a shoulder on the shell and the other against a shoulder on the nozzle, and means for positively rotating the nozzle on its longitudinal axis. Six claims.

839,867. FEED-WATER HEATER. Henry G. Miller, of Cleveland, Ohio, assignor to the Loew Manufacturing Company, of Cleveland.

Claim.—An apparatus of the kind described, comprising a casing, means for admitting steam into the space within, water tubes arranged in groups of tubes about the center of the casing, means for admitting water into one of said groups, means for conducting water from groups of said series respectively to the groups on the opposite sides of said casing, and means for discharging the water from the group on the opposite side of the casing from the group into which it enters. Five claims.

840,221. BOILER-TUBE CLEANER. Charles S. Knight, of Aurora, Ill.

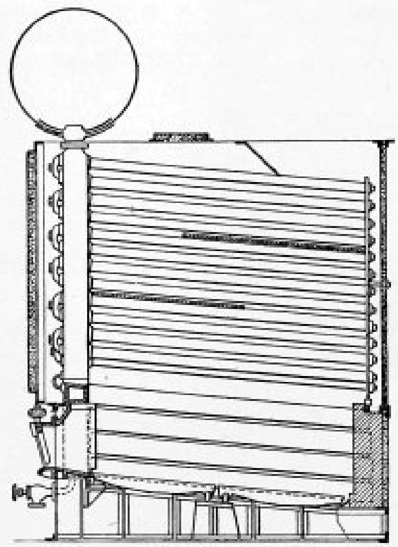
Claim.—In a boiler-tube cleaner, the combination of a central fixed stem having a reduced forward end with an exterior



screw thread and having slots on opposite sides of the reduced forward end and having a hole terminating in a screw thread within the end proper of the stem, a cutter head having a side wall encircling the fixed stem, a bearing for the front end of the cutter head, said bearing consisting of a cup and a cone with the cone threaded onto the reduced forward end of the stem, and a screw having a threaded advance end and a tapered body, and entered into the hole in the forward end of the stem for the thread to advance the screw and cause the tapered body to act and expand the reduced slotted end of the fixed stem and lock the bearing cone thereon in an adjusted position. Four claims.

841,593. BOILER. James P. Sneddon, of Barberton, Ohio, assignor to the Stirling Consolidated Boiler Company, of New York, N. Y., a corporation of New Jersey.

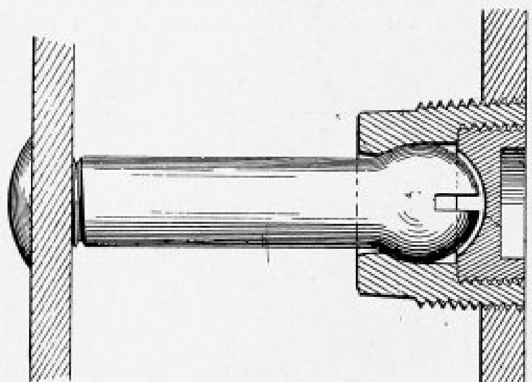
Claim.—A steam boiler furnace having front upright water legs, a steam drum supported thereon and in communication



therewith, headers depending from the drum between the legs and terminating short of the bottoms of the legs, and inclined water tubes leading rearwardly from the legs below the headers and defining a combustion chamber, the water tubes being in communication with the water legs only and having their rear ends closed. Twenty-four claims.

844,421. FLEXIBLE STAY-BOLT. Benjamin E. D. Stafford, Pittsburg, Pa.

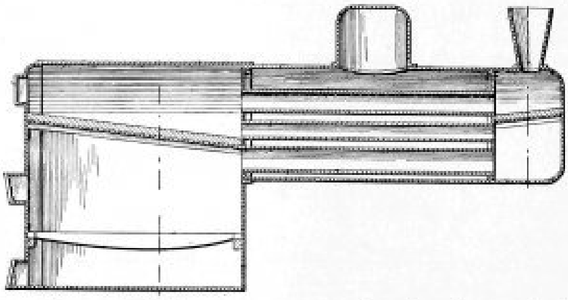
Claim.—A stay-bolt structure comprising a bolt having a head which is substantially spherical in form, a bushing having an opening for the passage of the bolt and a curved seat for that portion of the spherical head adjacent to the body of the



bolt, said bushing having an enlarged opening in its upper portion terminating in an annular shoulder, the wall of said opening being threaded, and a cap screwed into said enlarged opening and bearing against said annular shoulder, the inner face of said cap being curved substantially concentric to and spaced from the outer spherical portion of the head and the outer end of said cap adapted to lie flush with the outer end of the bushing. One claim.

840,725. STEAM BOILER. Ingebrigt J. Ullensaker, of Hatton, N. D.

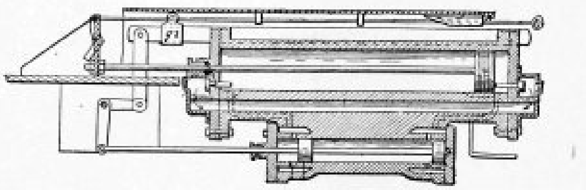
Claim.—The herein-described steam boiler comprising a cylindrical shell or casing having at its rear an enlarged rectangular portion, a transversely-extending stationary partition fixed in the front end of said casing, and inclined downwardly and rearwardly to divide it into upper an lower smoke chambers, a transversely-extending stationary partition fixed in the enlarged rear portion of said casing above the fire-grate therein and inclined downwardly and forwardly to separate its fire-box or chamber from the upper rear smoke chamber, a smokestack leading from the top of the upper smoke chamber at the front of the casing, a door closing a clean-out open-



ing at the end of the upper rear smoke chamber, and three horizontal rows of fire flues affording communication between the said chambers of the casing.

840,722. MECHANICAL STOKER. William Henry Strouse, of Oskaloosa, Ia., assignor to W. H. Strouse Manufacturing Company, of Oskaloosa, a corporation of Iowa.

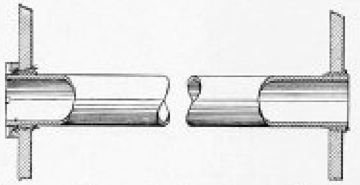
Claim.—In a mechanical stoker, the combination with a reciprocatory plunger located above the level of the bottom of the fire-box and having a fuel-projecting nose on its forward



end, of a plunger-operating cylinder and piston, a valve controlling the admission and exhaust ports of the cylinder, a valve gear operated by the plunger and embodying a hand-lever-controlled means for varying the extent of the forward stroke of the plunger during its operation to project the fuel a greater or less distance as desired. Nineteen claims.

841,381. DETACHABLE BOILER FLUE. Julian F. Drake, of Tracy, Minn., assignor of one-half to Joseph Kenna, of Ghent, Minn.

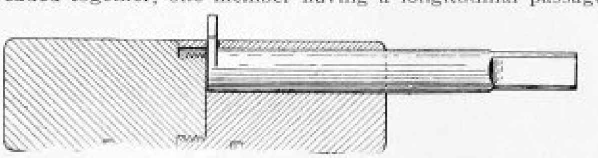
Claim.—In a boiler, the combination, with the flue sheets spaced apart and in parallel relation with one another and having tapered flue seats extending therethrough from one



side to the other, said seats being tapered in the same direction, one from the inner toward the outer surface of its sheet and the other from the outer toward the inner surface of its sheet, a flue extending through said sheets, and having a threaded end, tapered sleeves provided on said flue and fitting within said seats, said sleeves being tapered to correspond with said seats, packing rings interposed between said sleeves and seats and a lock-nut provided on the threaded end of said flue and whereby said sleeves and rings may be drawn snugly against said seats. Three claims.

843,499. FLUE CUTTER. Frank E. Shimer, Elkhart, Ind.

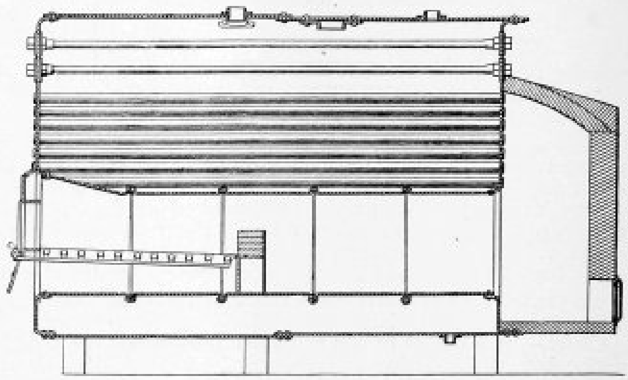
Claim.—A device of the character described, comprising a cylindric casing formed of two separable members screw-threaded together, one member having a longitudinal passage



arranged eccentrically to its axis and having a recess in that end joining the opposed member and a slot extending laterally through it and communicating with said recess, and a mandrel arranged within said passage and having an integral cutter extending at right angles therefrom, with parallel inner edges terminating in tapering outer cutting edges, said cutter adapted to practically describe an arc beyond the casing member, through which it passes, when performing the cutting operation. One claim.

841,513. STEAM BOILER. Ernst R. Gustavus, of Oshkosh, Wis.

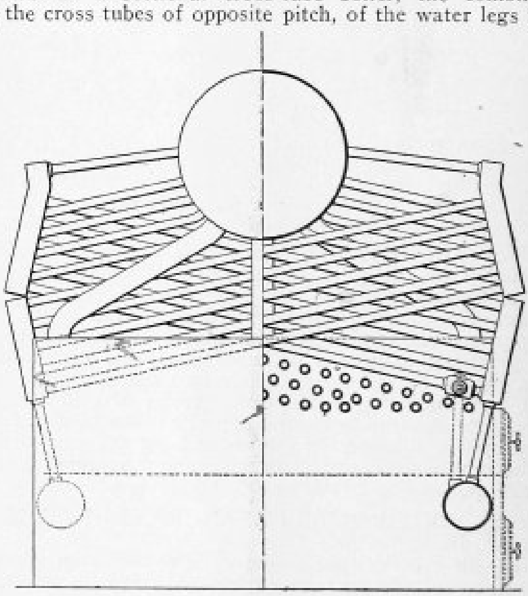
Claim.—In a steam boiler, an internal tubular furnace comprising in its construction sectional tubes having outwardly-turned circumferential flanges and means for joining said flanges, the front section being so constructed as to gradually



diverge circumferentially toward the front, said section being upon the same line of base as the other section, said furnace being suspended from inwardly-turned flanges around front and rear openings in the boiler heads, and removable means for attaching said furnace to said flanges. Two claims.

842,084. WATER-TUBE BOILER. Harry Del Mar, of New York, N. Y., assignor to Boilers & Engineering Company, of Jersey City, a corporation of New Jersey.

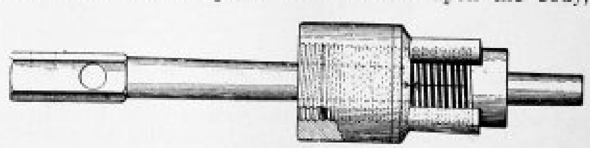
Claim.—In a sectional cross-tube boiler, the combination with the cross tubes of opposite pitch, of the water legs form-



ing the boiler sides and included in the circulation system, and tubes connecting the opposed water legs in the space formed by the incline of the aforesaid cross tubes. Ten claims.

843,865. FLUE EXPANDER. Joseph F. Brown, Bristol, Tenn.

Claim.—A flue expander comprising a tubular body having elongated apertures therein, said body being externally screw-threaded, a collar adapted to be screwed upon the body, a



sleeve adapted to be screwed upon the body and against the collar, said sleeve and collar having interior grooves, tapered rollers seated within the apertures and projecting into the grooves, and a mandrel insertible into the body for forcing the rollers laterally. Three claims.

THE BOILER MAKER

VOL. VII | MAY, 1907 | No. 5

THE SHOPS OF THE NEW JERSEY BOILER COMPANY.

BY CHARLES E. FRICK.

The works of the New Jersey Boiler Company, a general view of which is shown in Fig. 1, are located at Boonton, N. J. The main shop is 44 feet wide by 244 feet long, with a wing on the west side, 40 feet wide by 70 feet long. Due to its location, this company is able to utilize natural water-power for running its shop, and the power is distributed by line shafts on either side of the main shop. The loading and unloading of material, etc., is accomplished, as is clearly shown in Fig. 1, by means of a large derrick, located just outside the shop, which transfers the material from the railroad cars to trucks, which are run into the shop by hand.

Fig. 2 is a view of the full length of the shop, looking southwest, and shows the arrangement of some of the machinery; on the left is a Norwalk air compressor, operated by steam, and a Randall belt compressor. Beyond these machines are a heavy bending and straightening machine and a horizontal punch, both manufactured by the Cleveland Punch & Shear Works Company. On the opposite side of the shop are two Cleveland punches, one with a 42-inch throat, and the other with a 36-inch throat; both punches have a capacity for punching a 1-inch hole in 1-inch plate. Beyond the punches are a Lennox splitting shear and a Lennox bevel shear, both of these machines being capable of shearing 3/4-inch plate.

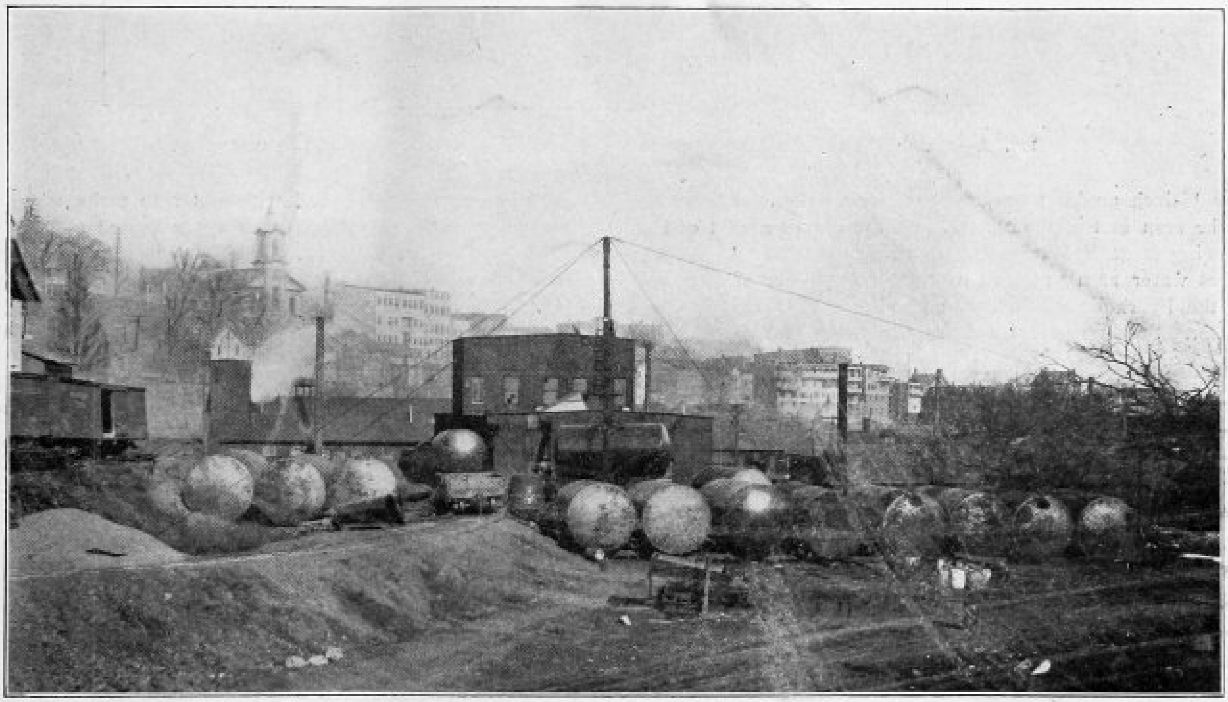


FIG. 1.—GENERAL VIEW OF THE WORKS OF THE NEW JERSEY BOILER COMPANY.

The material is handled at these machines, and throughout this part of the shop, by five overhead cranes, spanning the entire width of the shop and each operating for a distance of 150 feet. Each of these cranes has a capacity of 3,000 pounds, and all are equipped with ball-bearings, so that they are very easy to operate by hand. The material is conveyed to different parts of the shop on trucks, one of which is plainly shown in Fig. 3. These trucks are equipped with roller bearings, and are arranged so that several men can push them about with ease, even when loaded quite heavily. Upon the erecting floor are two 10-ton cranes, equipped with 5-ton Yale & Towne chain hoists. These cranes are also equipped with roller bearings and can be handled easily.

Fig. 3 is a view of the wing looking west. The blacksmith and flange-fire forges are in this department, and also a heavy angle-iron roll, manufactured by the Bethlehem Foundry & Machine Company. This machine is capable of rolling 4 by 4 by ½-inch angles to a complete circle. Some of its work can be seen in the photograph. At the extreme west end of the wing is an hydraulic pump and accumulator, which furnishes water at a pressure of 1,500 pounds per square inch for the hydraulic machinery, and also a Franklin air compressor. Steam is furnished for the pump and compressors by a 70-H. P. locomotive type boiler, which is also located in the wing.

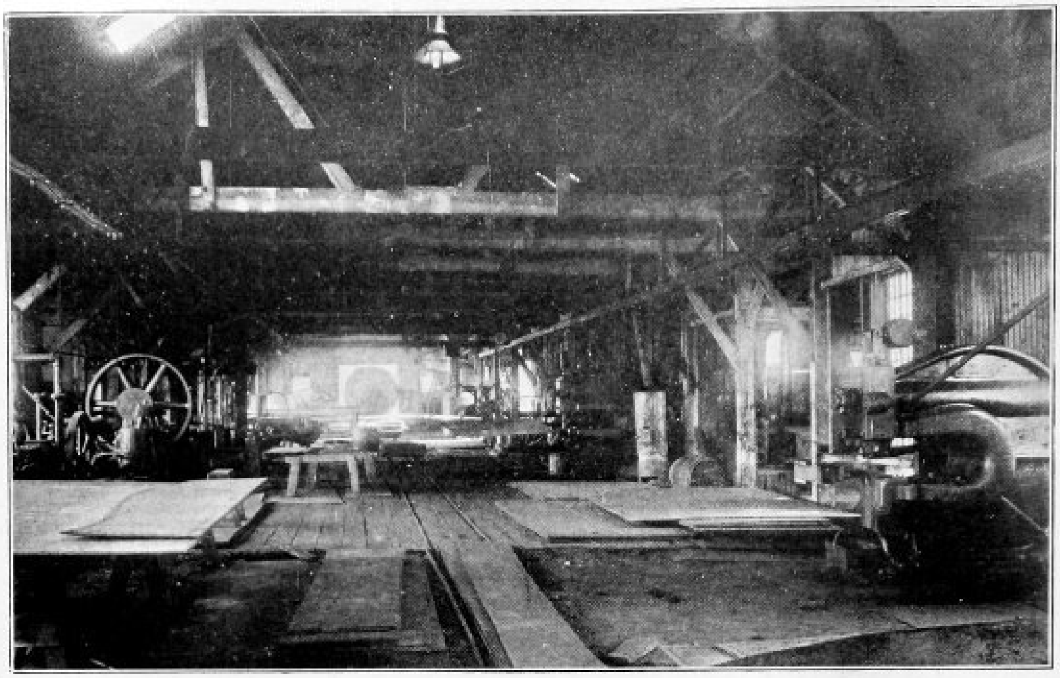


FIG. 2.—VIEW IN THE MAIN PART OF THE SHOP OF THE NEW JERSEY BOILER COMPANY.

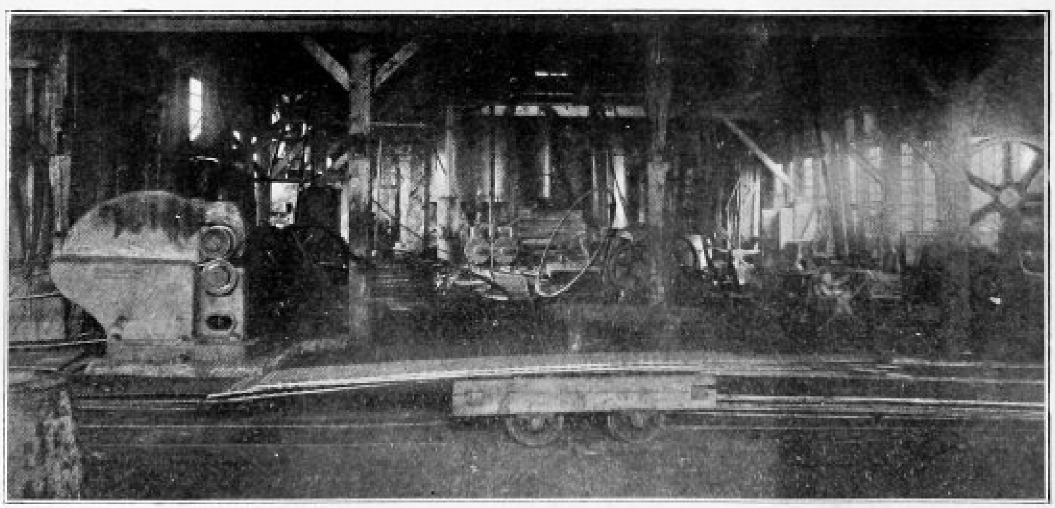


FIG. 3.—VIEW LOOKING WEST IN THE SHOP OF THE NEW JERSEY BOILER COMPANY.

Fig. 4 is a view showing the erecting floor. The bending rolls, which are shown at the left, are capable of rolling ¾-inch plate to complete circles. Opposite the bending rolls is a large hydraulic riveting machine, capable of driving 1¼-inch rivets. This machine has a gap of 10 feet 6 inches. The variety of work turned out by this company is well illustrated in this view. The forty-five degree bends which are shown are 48 inches in diameter, constructed of ½-inch material, riveted together with ⅞-inch rivets. They are calked inside and out and then filled with water to make sure that there are no leaks. Afterwards they are heated and dipped in asphaltum before shipping. These bends are part of the work which was done on a contract for the Philadelphia water mains.

Several large ladles, made of ⅝-inch material, are also shown. The trunnions and spouts are of cast steel. This company manufactures a large number of these ladles. In the doorway on a truck may be seen a large tank ready to be pushed outside and tested by air at 40 pounds pressure. Fig. 5 shows several of these tanks outside, undergoing a test of this sort. They are 10 feet in diameter by 21 feet 8 inches long and are constructed of ¼-inch plate with ⅜-inch heads.

Technical Education of Railroad Apprentices in the Missouri Pacific Railway Shops at Sedalia, Mo.*

BY S. M. DOLAN, MASTER MECHANIC MISSOURI PACIFIC RAILWAY.

There is nothing new in the idea of affording boys who are learning a trade an opportunity to supplement their work and instruction in the shop with studies in arithmetic and higher branches of mathematics, as well as mechanical drawing and other studies, a knowledge of which is essential to their respective occupations. John W. Garrett, for many years head of the Baltimore & Ohio, planned a school at Baltimore, Md., for apprentices in all lines of railroad work, the intention being to draw on the graduates of this school for the railroad's future officers; I think this was in 1884 or 1885. A prospectus of this school stated it would be known as the Baltimore & Ohio Technological School, and apprentices in employ of the company passing a certain examination would be entitled to admission and would be given employment at Baltimore in shops or offices of company. Either through indifference of the apprentices and their parents, or other reasons with which I am not familiar, this project did not go through and was probably abandoned. This same subject came up at the annual meeting of American Railroad Master Mechanics' Association, in 1895, I believe, and in 1896 a committee made a report that was discussed at length, the members showing a keen interest in the matter, this interest being exemplified by the fact that over 300 replies had been received by the committee in answer to the questions sent out.

The necessity of a supplementary education seemed to be

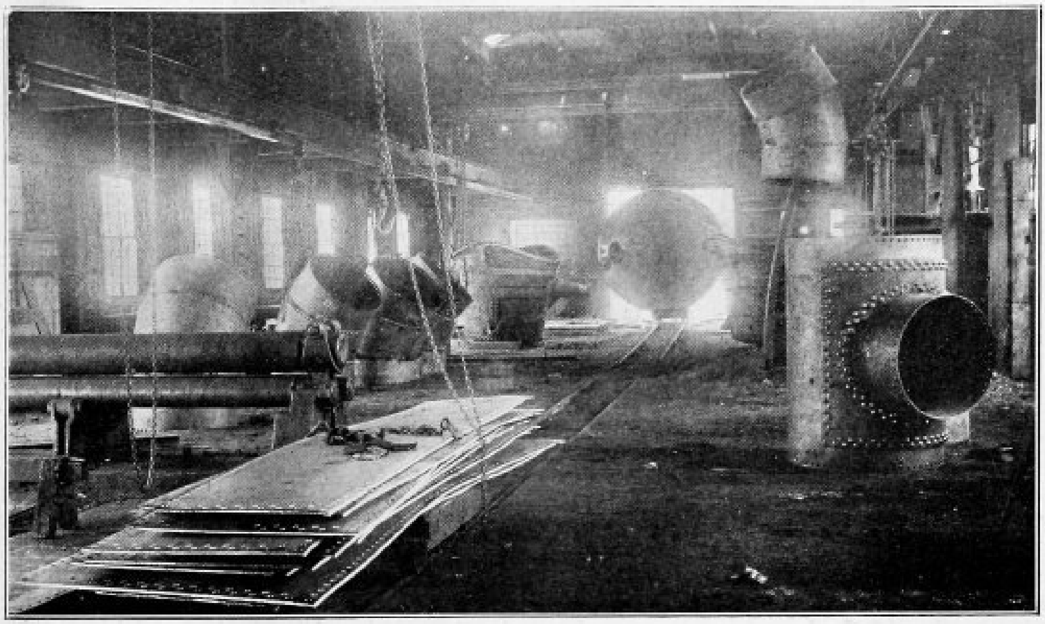


FIG. 4.—THE ERECTING FLOOR IN THE SHOP OF THE NEW JERSEY BOILER COMPANY.

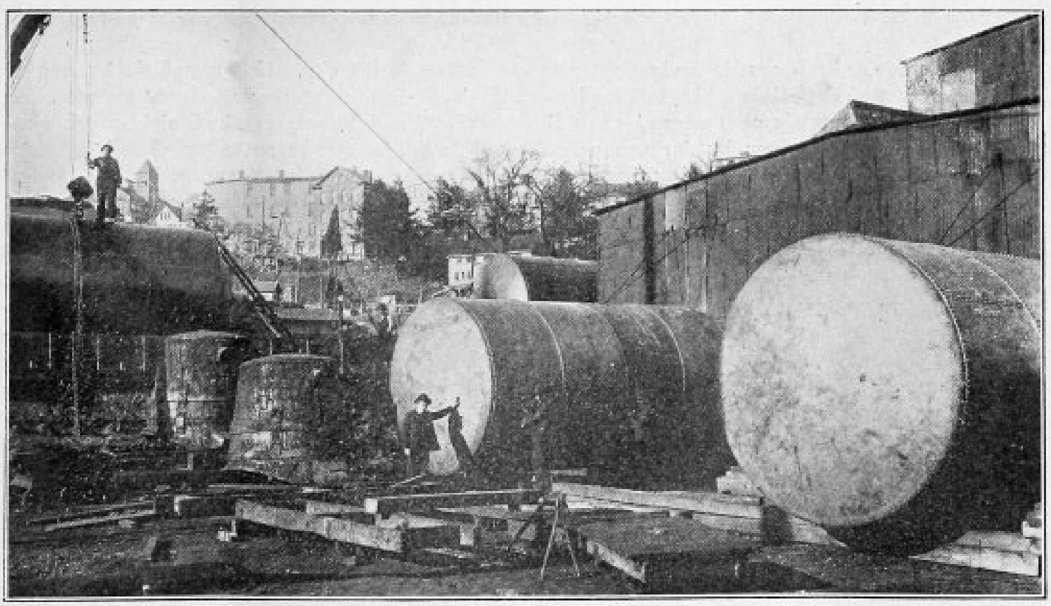


FIG. 5.—TANKS UNDERGOING TEST AT THE NEW JERSEY BOILER COMPANY'S WORKS.

* Presented before the St. Louis Railway Club.

recognized by all, either through a course of lectures by regularly trained instructors, draftsmen, or other employees of the railroad competent to teach, it being generally understood that classes would be held after regular working hours. In this respect education of apprentices at Sedalia differs from the plan followed by any railroad as far as I know, the students reciting their lessons during regular working hours of the shop and without loss of time to the boys themselves. The beginning of this school dates back to April 20, 1906. Through an arrangement with the management of the railroad company, and active interest of Mr. George W. Smith, surepintendent of machinery, the general manager of a well-known correspondence school, brought instructors to Sedalia, and with the assistance of the master mechanic, assembled all of the apprentices, sixty-two in number, and briefly explained what it was proposed to do for them. The only restrictions were that the apprentice be under twenty-one years old, as boys of that age were practically out of their time, and had reached an age of mind that does not easily take new impressions. The various trades represented were as follows: Boiler makers, machinists, blacksmiths, electricians, tin and coppersmiths, painters and carpenters.

No regular school room being available, the coach paint shop, at that time unoccupied, was used, and being well lighted and heated, proved a very satisfactory location. The boys were divided in squads of three to five without regard to occupation, the foreman being consulted as to the time each boy or group could be spared. The co-operation of the foremen was solicited and readily given, they being invited by the master mechanic to spend at least 15 minutes per day in the class room during the time boys in their own gang or department were reciting. After the squads were made up, an assignment of time was made, squad one reporting at 7 A. M., squad two at 7:30, squad three at 8 and so on, the last squad reporting about 2 P. M. At the expiration of thirty days, a readjustment was made, the five boys leading in their studies being assigned to the same squad, this plan being as closely followed as conditions would permit. This adjustment has continued from month to month.

Soon after opening the school, sets of drawing instruments were offered to the five students having made the best progress in their studies at expiration of sixty days. This had a stimulating effect on all. Later on, fountain pens were given to all who performed a certain number of examples during a period of sixty days; sixteen of the students qualified in this contest. These prizes were given by general manager of the correspondence school, who has at all times taken a personal interest in the students and their studies.

When the class first opened, and for the first sixty days, instructions were given by two young men with university training. Later on this work was assumed by an instructor with university training, supplemented by correspondence school study, also eight years as locomotive fireman and engineer. There is no doubt his personality has contributed in a marked degree to the success of the school. As these shops only went into operation in October, 1905, practically all of the boys were in the first year of their apprenticeship, the only exceptions being those transferred from other shops. The rules of this company require that all applicants for position of apprentices before being employed pass successfully an examination, consisting of four examples in arithmetic, and receive at least 75 percent in writing and spelling. This rule was rigidly enforced at Sedalia.

The subjects taught are arithmetic, elements of algebra, logarithms (common), geometry, trigonometry and drawing. Arithmetic includes addition, subtraction, multiplication and division of whole numbers, fractions and decimals, percentage, involution and evolution, ratio and proportion. Algebra includes addition, subtraction, multiplication, and division, to and including quadratics containing two unknown quantities. Logarithms is the Briggs or common system. Geometry and trigonometry take up the study of geometrical construction, mensuration, and a portion of plane geometry. Under trigonometry the handling of the functions, tables, etc., and how they are obtained is explained. The course in drawing is as complete as it can be made, and has been made to conform as nearly to actual office practice as possible. It includes geometrical and mechanical, thirty plates in these two subjects being required of each student; practical projections, four plates, development of surfaces, ten plates. Mechanical drawing also gives detailed information regarding handling of blue prints and making same.

As to their individual advancement the following report from the instructor submitted recently may be of interest, students' records being selected at random:

Student (A), machinist apprentice, never reached the sixth grade in public schools, could scarcely add two fractions, knew nothing of decimals or beyond that. Has finished arithmetic and can use it, is finishing algebra and is doing splendid work in the mechanical drawing.

Student (B), machinist apprentice, sixth grade in public schools, has finished arithmetic, is finishing algebra, and is progressing nicely in mechanical drawing.

Student (C), blacksmith apprentice, never finished fourth grade in public schools, couldn't do a long example in long division, has finished arithmetic, is now in algebra, and is doing some of the best work in the class in mechanical drawing.

Student (D), boiler maker apprentice, did not get beyond the fourth grade in public schools, has finished arithmetic, and is now in algebra, and is just beginning his mechanical drawing proper.

The boy farthest advanced in all studies at present time had only reached the fifth grade in public schools.

The time lost by apprentices from their regular shop work will average perhaps 20 minutes per day, as all their studying is done in their own time, usually at home, but a large number use the study room of the correspondence school, located conveniently in the city. No great difficulty was experienced in the beginning in securing regular attendance. As the novelty wore off and lessons required night work and considerable self-denial, interest began to lag. The laggards were taken to task one by one by the master mechanic, and kindly but firmly given to understand that regular attendance and progress in studies were as necessary as satisfactory service in shop. Two quit, no doubt rather than pursue their studies, one was dismissed, refusing to study, his work in shop justifying this course. This seemed to be the critical point, and meant either failure or success of the venture. While the difficulty of maintaining interest did not end here, there was a marked improvement, which has continued without interruption to the present time. In fact the greatest rivalry of a friendly character exists between the different squads and individual students.

With this information you are, no doubt, convinced that the school has been a good thing for the apprentices, but you are probably wondering where the company gets returns for its investment. It took a broad-minded and liberal, but far-seeing management to start a school of this kind, for with best results, immediate returns could not be expected. The following letters, however, may serve to show some of the advantages already gained by the company from this school.

From Master Mechanic to Superintendent Machinery:

"As to the immediate and present advantage to this company to offset the cost through loss of time while they were reciting their lessons and the expense of instruction, it would be difficult to determine, and might be compared to an improvement on the locomotive that we felt satisfied was resulting in a more economical operation, but would be unable to determine its value in dollars and cents. I claim as an advantage to us, that it has resulted in less laying off among the pupils for the reason that their absence from work meant absence from their recitations, and an increased effort to hold their own with the class. It has also aroused a spirit of inquiry that extends to their work, and has made them more useful employees through their ability to do a class of work, a knowledge of which might have not been acquired until the latter part of their apprenticeship, if at all. There is no doubt in my mind that it has also created a feeling of emulation among aspiring and ambitious mechanics, with whom these boys are associated, and whose knowledge gained in the school, enables them to lay out work and solve problems that could not be done by the ordinary mechanic.

"Looking at the subject in this manner, I believe that I can safely say that the company has, and will continue to be, the gainer by furnishing this education to their apprentices, and certainly if they retain in their employ only 50 percent of the apprentices that pass through this school, they will have a high grade class of mechanics that will enable them to operate their

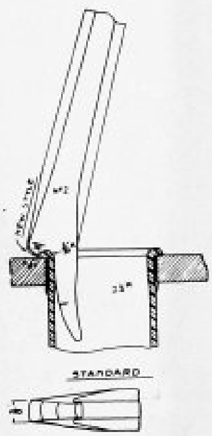


FIG. 1.—STANDARD BEADING TOOL.

shops in a more economical manner than with the present class of men they are able to secure."

From Foreman of Boiler Shop:

"In reply to your letter of the 17th inst., relative to the advantages gained by apprentice boys in the correspondence school here, will state that I have noticed a remarkable improvement in the interest they are taking in their work in the past six months. I know this from experience, as the boys are constantly asking me questions about the construction of boilers, and as to the repairs of same, in fact all of our boys in boiler shop that are attending this school are doing some of our best boiler work in this shop, and I am satisfied at the expiration of four years these boys will be finished mechanics. It is my opinion that this school given to apprentice boys here is a great advantage, and I know the boys appreciate same."

There is no expense to this, as far as pupils are concerned, except for pencils, scratch pads, etc., although required to buy their own drawing instruments. Cost of instructor and reviewing of papers and written lessons at headquarters of correspondence school are arranged for by the railroad company.

In conclusion, I can only add my belief that the railroad company has and will continue to benefit in a very substantial manner from the education extended to their apprentices, and what has been done at Sedalia, can be done in any other railroad shop or industrial concern, if co-operation of those in charge can be secured and the instructors properly backed up. Otherwise, the results will not be worth the trial.

A Layout for a Boiler Maker.

BY A. N. LUCAS, GENERAL FOREMAN BOILER MAKER, C. M. & ST. P. RY. CO.

Do not be a lusher; break away from the old rounders who won't be lifted up. Aim to better your conditions. Be a boiler maker and be proud of it. Watch the first-class workman and make yourself his equal or better. Have an eye for good tools and good work. Take an interest in the men and the shop you work in. Ask for information; look for results. In doing boiler work, good judgment is necessary, without it you are a failure. Just think of a boiler maker putting in a set of copper shims, then pounding on the expander so hard as to warp the sheet badly, and then expanding the flues, using the same judgment. You can imagine the condition of the flue sheet when flues are finished.

FLUE WORK.

In working flues, considerable judgment must be used. It is practically a trade of itself.

The method used by the writer is to remove the burr off the flue holes inside and out, then apply copper shims flush with the sheet, expanding same with a copper shim expander. The

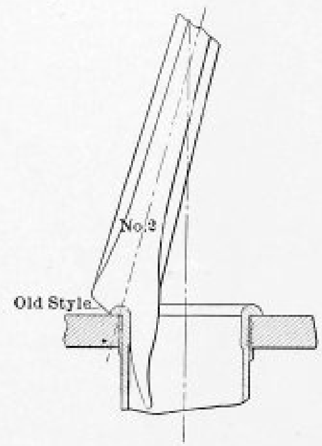


FIG. 2.—OLD-STYLE BEADING TOOL WITH SHARP HEEL.

flue is then swedged down so as to fit shim snugly. All scale should be removed from the flue end before applying. The flue is then shoved into the boiler, allowing 3/16 inch to 1/4 inch for the bead. Catch the flue slightly with pein of the hammer. Do not take more bead than you want, figuring that the flue will go back when expanded. Turn the flue over slightly at the outer edge. With the face of the hammer upset the edge all around, which will leave the flue smooth, ready for the expander. Expand the flues, turning the expander four times, half the width of a section each time, using a 4-pound maul. The idea is to work the flue in the sheet, and in doing so work the sheet as little as possible. You cannot but notice the poor condition of the top flange and top flue hole, most all of which is due to the improper use of the expander. With this method, you will find the bead up against the sheet in a smooth condition, which allows the expander to go inside of the sheet as it should, turning the flue partly down when expanding.

You may find that the expander goes in on an angle on account of the bead not being down all around. This helps to make a very poor job. You sometimes have a large flat bead, due to turning the bead over with too large a radius. Then when you take a standard beading tool to calk this you will have to hold the tool at an improper angle so as to catch the outer edge of the bead, since the bead is too large and flat. After you have gone around the flue a couple of times you will notice that the top of the bead has not been touched by the bottom of the tool, and to get it to do so you have to go around the bead a few times more to work it up into the beading tool. This is not good practice. If you will turn the flue over slightly, upset it with the face of the hammer, expand it properly, and then calk the bead with a standard beading tool, you will have a nice, high and strong bead, which the fire will not affect as it will a large flat bead. (See Fig. 1.)

In working old flues, expand them slightly with a sectional expander, turning the expander three times around, using an ordinary plugging hammer, weighing about 2½ or 3 pounds, with a handle about 18 inches long. Just remember that in expanding old flues, it does not require the pounding to tighten the flue in the sheet, as it already has the full contour of the expander.

In beading old flues a couple of times around is sufficient, holding the tool at a proper angle always. If the bead is large reduce it with a flat chisel or tool made for that purpose. Never undertake to reduce the bead with a beading tool, as this invariably tends to cut in the sheet and work the flue away from the sheet. At the same time be careful in all cases when calking flues not to cut a groove in the sheet around the flue.

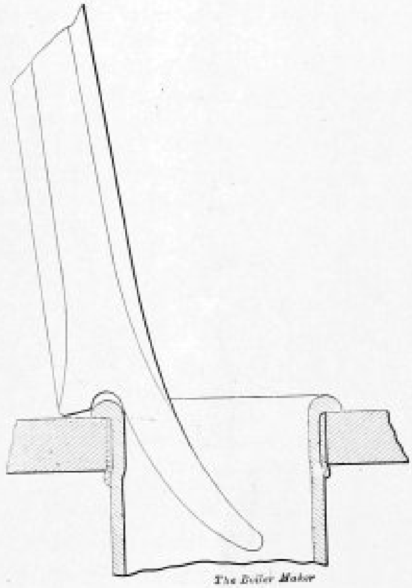


FIG. 3.—BEADING TOOL WITH BLUNT HEEL.

This shows very poor judgment and should be watched closely by all boiler makers. (Sketch No. 3 showing tool with blunt heel to overcome same.) Remember that if you run across or have a small bead it cannot be calked with a standard beading tool. Have another tool with the heel ground off to calk the small bead. This is to avoid cutting into the sheet, forming a burr at the outer edge of the flue hole and driving the flue away from the sheet. (See Fig. 4.)

In working old flues in a round house you often find the flues partially filled up inside on account of leakage. Before expanding these flues they should be properly cleaned out, especially just inside the sheet. This is to prevent cracking the flue when expanding it. Too many flues are bursted from the above cause. Use a little more judgment in such work. Also note the condition of the expander end of sections battered up badly, due to carelessness in knocking the pin loose. This is the main cause of breaking so many sections. It is also dangerous, as the sections are hard and pieces broken off are liable to cause injury or the loss of an eye.

ARCH FLUES.

When applying arch tubes, to get the length and proper shape, take a templet and square that we have for this purpose in the fire-box. Place the same in position, using the square to see that the templet is in at right angles with both sheets, allowing 5/16 inch for bead. Then take the templet out and place it on the arch flue. If the arch flue is correct to templet, cut it to length, file off the burr, anneal both ends, put copper shims in the flue sheet flush with the sheet, place the tube in position, holding it with a clamp or spud while it is being rolled, then turn it over and bead it properly, rolling it again lightly after beading. Always be sure and bead the flues, as they are liable to pull out of the sheet if not properly beaded.

PATCHING.

In applying patches, first mark off the patch, allowing 13/16 inch for lap. Lay out holes 1¾ inches for 13/16-inch patch bolts. Center pop quite heavily, also center pop the stay-bolts. Place a piece of paper over the defective part, and with the pein of a chipping hammer tap slightly on all center pops. You will then have a correct pattern of the patch. Be sure and mark the top. All holes can be punched and the patch beveled, allowing ⅞-inch lap.

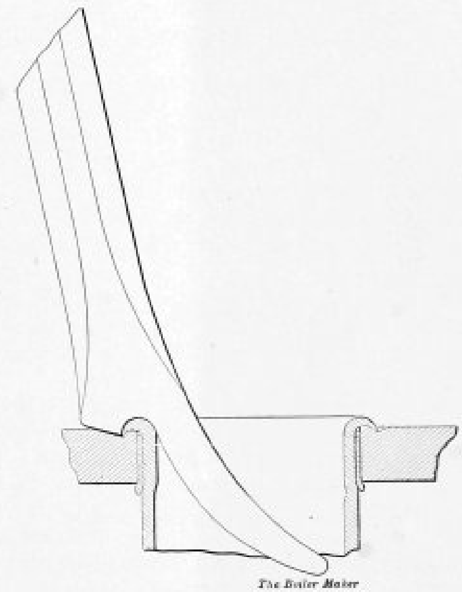


FIG. 4.—DAMAGING EFFECT OF OLD-STYLE TOOL.

While the patch is coming along, the defective part can be cut out, and if bulged and uneven the sheet should be warmed and straightened. Drill and tap four holes for patch bolts, one on each side, and one on the top and bottom. Enlarge these four holes in the patch 1/32 inch larger than the patch bolts. Bolt up the patch with four patch bolts, and then drill the balance of holes through. This will insure perfectly fair holes. Take off the patch and have all holes countersunk and enlarged 1/32 inch larger than the patch bolts. Tap all the holes in the sheet; remove all burr and scale from both new and old sheets, put the patch up again and apply all the patch bolts. Lay the patch up against the old sheet, draw up the bolts again and see that the patch is perfectly tight around the bolts. Then start and twist off the patch bolt head. Draw the sheet and bolt up with the pein of the hammer. Pull up the next bolt; twist off the head and continue until all the heads are off and the bolts ready to work. Work the bolts down with a drift pin or hammer, then calk slightly with a straight frenchman or rivet tool, having no bevel on same. Calk the patch with a square tool and then lightly with a thin tool.

When you have the sheets laid together properly, it requires but light calking. Too heavy calking would disturb the patch bolts or rivet heads, and have a tendency to separate the sheets at the calking edge. (See Fig. 5.) Be careful, when calking at any time, to see that you do not hold the tool so that you will cut or work the lower sheet.

When the patch leaks, which, of course, it will in time, work the patch just the same as if you were applying a new patch. Draw the sheets up around the bolts. Work the bolts down with a drift pin, then calk slightly with a straight rivet tool, also using a square tool slightly. Be sure and do not cut a groove in the patch around the patch bolts. In case you find

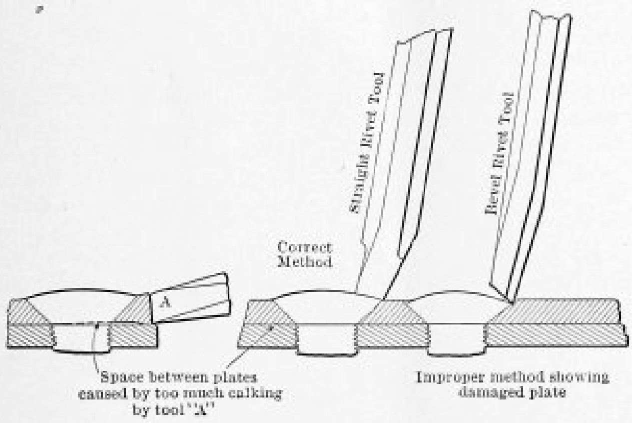


FIG. 5.—EXAMPLES OF CALKING.

such a groove work it out with a drift pin. Never use a beveled rivet tool, as it is impossible to calk patch bolts or rivets with it. (See Fig. 5.)

PLUGGING CRACKS.

When you have a short crack in side sheets and are not going to plug it, do not chop in each side of the crack with a thin fuller, but work it over nicely with a thick fuller. Hide it so it cannot be found until it leaks again.

Cracks in door rings can be hammered up with the pein of a chipping hammer, using no tool whatever on them. When it comes time to plug the crack, use no plugs smaller than ½ inch, drilling a ⅜ inch hole to start with. Tap out and point the plug so that it will screw in perfectly tight, about two threads through the sheet. Cut it off, allowing one thread for the head. Drill the next hole so that the next plug will join on to the first plug. When all the plugs are in, see that they do not project over one thread, and then work them down nicely with a thick fuller. (See Fig. 6.)

The above methods will give good results, and if each boiler maker receives the same instructions and carries them out, patches and cracks will stand much better and fire-boxes will not look as though repairs have been made by a butcher instead of a boiler maker.

STAY-BOLT WORK.

In applying bolts in new sheets the holes should be properly threaded, and the bolts should be made a nice ordinary fit, not too tight. When bolts are being put in and set, any which show that they are stripped or partially stripped, should be taken out, the hole retapped and a new bolt applied. The bolts should be cut off, allowing two and one-half threads at each end for riveting.

In renewing broken stay-bolts in a roundhouse or back shop, care must be taken not to spoil the thread in either sheet, as the same size bolt will be applied in all cases where we have a good thread. If it is necessary to cut the heads

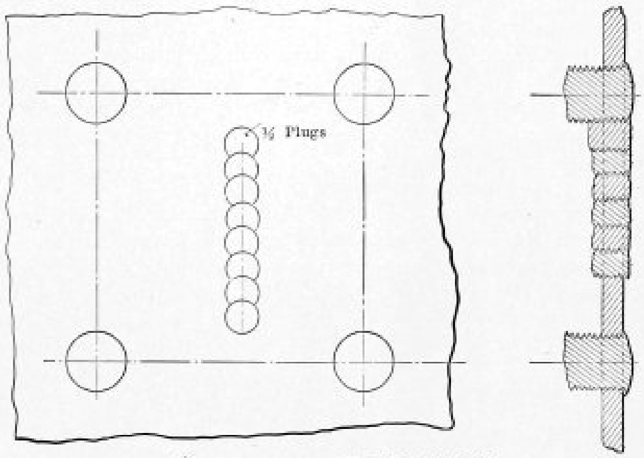


FIG. 6.—METHOD OF PLUGGING CRACKS.

off before drilling, do so. This is to prevent the drills from cutting the sheet. When the plate is bulged between bolts in the side sheets through the center of a fire-box and the bolts have to be renewed on account of leaking, we will apply a combination bolt, tapping the inside sheet until we have a good thread. The outside sheets should remain the original size as long as possible.

All bolts renewed in the roundhouse should be drilled for tell-tale holes before they are applied, and the bolts should be screwed in from the inside of the fire-box, in order to save drilling the tell-tale holes in the roundhouses and outside points.

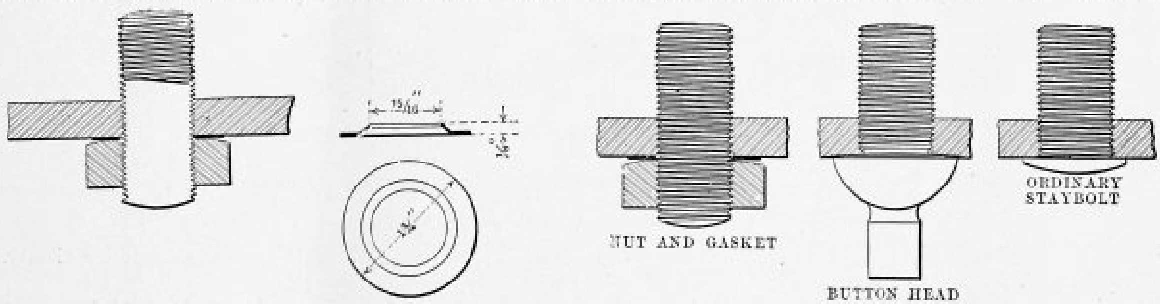


FIG. 7.—STAY-BOLT WORK.

RADIAL STAYS.

In applying and renewing radial stays, care should be taken to see that you have a full thread in both sheets. In applying the stay, you should be sure and see that the thread matches perfectly with the thread on the tap. This is to avoid stripping the thread off the bolt at the lower end.

It is now the practice of the writer in applying radial stays to have the eight center arch rows project through the sheet 13-16 inch. We then apply a light copper gasket and a ⅝-inch steel nut, cutting off the stay outside, holding on inside, riveting up on the outside and then retightening the nut. You will note that the copper gasket is punched out on a special die, with the hole the correct size to just go over the bolt. When the nut is tightened up against the copper gasket, it straightens and closes up the gasket, decreasing the size of it and making it fit perfectly tight on the bolt, thus giving good results. Other roads are using a bolt with a button-head screwed up from the bottom. A sketch of the bolts and gaskets is shown in Fig. 7.

In renewing radial stays, care should be taken in drilling out, so as not to break a bolt off or drop it on the crown sheet, or in the leg of the boiler, where it cannot be taken out readily, making it necessary to remove the dome cap and standpipe. Our bolts measure 1⅛ inches on top and 1 inch on the bottom. Our method is to drill a ½ inch hole in the top end from 1½ to 2 inches, then drill a larger hole through the sheet, drilling off the upset end. We then drive a pin in the ½ inch hole for a guide, drill the bolt loose from the under side, pull it out through the top, retap and apply the new stay.

RENEWING SHEETS IN FIRE-BOXES.

In renewing the sheets in a fire-box, after the old sheet has been cut out and the new sheet has been flanged to correspond to the size of the sheet removed, all holes should then be marked off, punched or drilled and countersunk. The new sheet is then put in place and the flanges and laps heated and laid up closely. All the holes should be fair before a gang is put on to rivet them. Good holding on is necessary. Plug the rivet in good shape and draw up the flange or sheet all around the rivet. Then with a plugging hammer thin down the edge of the rivet as much as possible. Finish the job with a bevel-face hammer, as this is much better than chopping in the sheet around the rivet with a bevel-face rivet tool.

RIVETING MUD-RINGS.

The rivets should be held on with a sledge, back-riveting on the same while the rivets are being plugged. Then lay up the sheet, back-rivet the head with a light maul, holding on outside with a holding-on bar, heavy enough to overcome the blow of the maul on the head. This is to avoid having loose rivets after being back-riveted and will insure tight work when finished.

DUTIES OF AN INSPECTOR.

When an engine comes in to the shop for repairs, the inspector should locate all defects in fire-box and mark them. The foreman should decide upon and mark the necessary repairs to be made.

When the flues are removed and the boiler properly scaled, the inspector should make a thorough inspection from the inside of the boiler, looking closely for corrosion on the seams, bottom of the shell and root of the flange on the front flue sheet. Also look for defects in the top corner of the throat sheet, and in the top row of stay-bolts in the side sheet. Look for cracks in the roof sheet. Inspect all braces; locate all broken stay-bolts. It is a good plan to sound all stay-bolts shortly after the boiler is shopped, renewing all broken stay-bolts possible before the final test is made.

BUILDING NEW BOILERS.

Good laying out is necessary. Care should be taken that all holes are punched or drilled where marked, as, nowadays, putting in sheets and marking off holes is a thing of the past. Good flanging correct to size, so that the sheets will come together properly, and insure good holes is necessary. All sheets, to be rolled, should be correct with sweep. Much depends on good fitting up. The sheets should be laid up closely, depending very little on the rivets to pull them together. The holes should also be reamed before going to the riveter. This will insure first-class work.

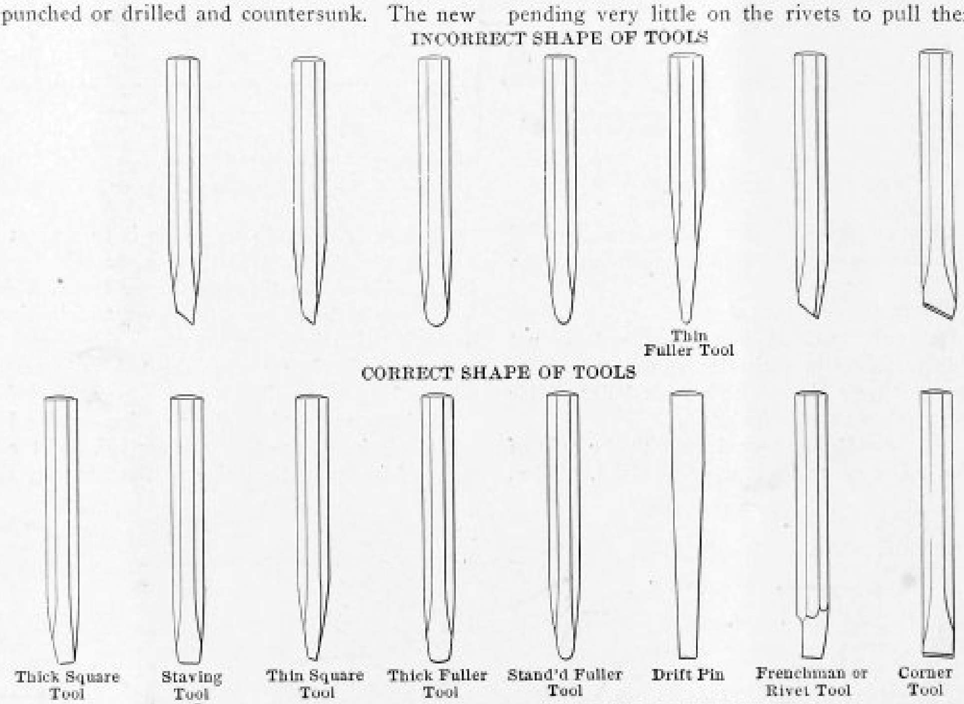


FIG. 8.—CORRECT AND INCORRECT SHAPE OF VARIOUS CALKING TOOLS.

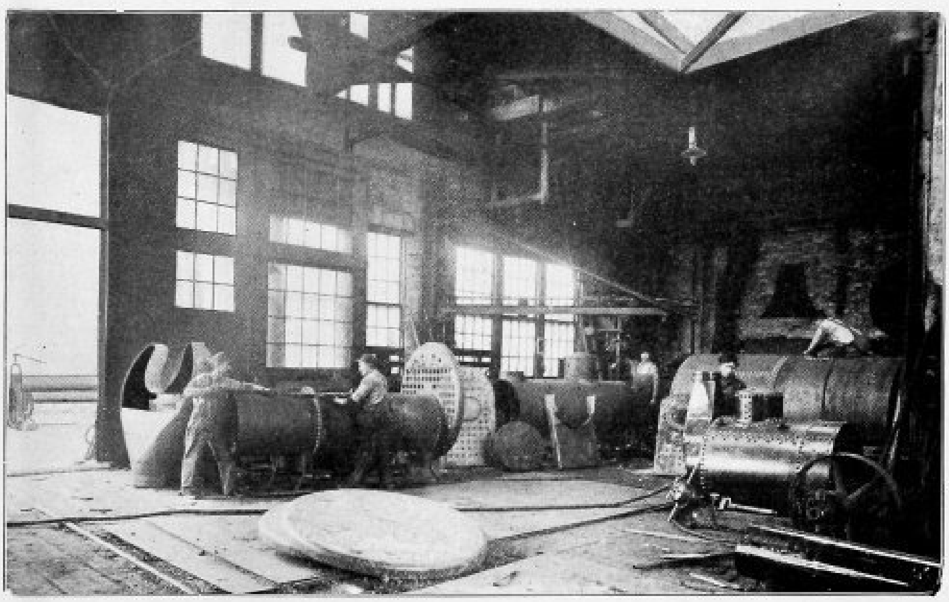
When sheets are only partly fitted up ⅛ inch to ¼ inch apart, the holes reamed in this condition leaving the burr between the sheets and then sent to riveter, the sheets will not be together properly. There will be a collar on the rivets between the sheets. The rivets will not be as good as they should be, as it will require much more calking to make the boiler tight.

The modern boiler of to-day, properly constructed, is a safe proposition when used with proper care. There are but a few cases on record of explosions, due to poor material, poor construction or poor workmanship. Almost all explosions are due to improper care or to low water. The amount of damage done in each case, heavy or light, is due to the pressure, location of water and condition of the fire at the time of the accident. There may be low water, a low fire and full pressure and no damage done; or low water, a heavy fire and no pressure and the damage done would be very slight. But when you have low water with full pressure and a fire heavy enough to overheat the sheets, you can rest assured that there will be some damage done.

Boiler Shop of the Marine Iron Works.

The boiler shop of the Marine Iron Works, Chicago, Ill., a view of which is shown herewith, is small and compact, but it is of recent design, and has been very completely equipped. The most modern types of machinery have been installed and each machine, with the exception of the air compressors, is driven by a separate electric motor. The plates for the boiler shells are bent in a set of heavy 10½-foot rolls, electrically driven. The plates are prepared by means of a good assortment of fairly heavy drilling machines, splitting shears, bevel shears, etc. Very little hand work is done, as there is a complete outfit of pneumatic tools for use on the erecting floor, most of which are the product of the Chicago Pneumatic Tool Company. An overhead crane serves to move the material and unfinished work from one part of the shop to the other.

This company does very little boiler work outside of that required for the propelling machinery which they build. They are prepared, however, to manufacture and install all types of propelling machinery for marine work in units of from 20 to 750 H. P., including all the auxiliaries and accessories.



VIEW SHOWING ONE CORNER OF THE BOILER SHOP AT THE MARINE IRON WORKS.

Boiler Explosions During 1906.

The total number of boiler explosions in 1906, according to the best information we have been able to obtain, says *The Locomotive,* was 431, which is nineteen fewer than were recorded for 1905. There were 450 in 1905, 391 in 1904, 383 in 1903, and 391 in 1902. The number of persons killed in 1906 was 235, against 383 in 1905, 220 in 1904, 293 in 1903, and 304 in 1902; and the number of persons injured in 1906 was 467, against 585 in 1905, 394 in 1904, 522 in 1903, and 529 in 1902. The average number of persons killed, per explosion, during 1906, was 0.545, and the average number of persons injured, but not killed, per explosion, was 1.083.

WORD is received of the death on February 21 of Mr. William C. McMillan, president of the Detroit Seamless Steel Tubes Company, Detroit, Mich.

The Design of Heads for Tanks Under Pressure.

In the manufacture of large flanged and dished heads it is the usual practice to first cut a circular plate enough larger than the desired finished diameter to give the metal necessary for the flange and lap, after allowing for the increase required by the dishing. This plate is then heated red hot and placed on a form or mould, into which it is squeezed by an hydraulic press or other means until it has the required dish shape. The dished head is then firmly held down in place by a large die and slowly revolved, while at the same time a wheel, pressed against and rolling over the outside of the head, spins up the flange against the corner of the die all the way around. Sometimes the wheel fails to spin the flange fully up, or else the finished outside diameter of the flanged head may be a little too large for the shell with which it is to be used, and in such cases it occasionally happens that the flange is brought up to the desired point or its outside diameter is lessened by holding a fulling tool against the inside of the knuckle of the flange and striking this tool with a heavy sledge.

Whether the fuller and sledge are used or not, there is usually some thinning down of the metal of the plate at the knuckle, just where the curvature is sharpest. If the fuller and sledge are used in the manner described the result is a well-defined groove, almost amounting in its effect to a continuous nick around the inside of the knuckle. While the use of the fuller and sledge is indefensible, the temptation to resort to it to bring the head to shape or size, when the work has to be done in a hurry and when there is no time to send the head back to the mill, is hard for a contractor to resist.

A year or more ago a large steel cooker burst, completely demolishing the building in which it was located, killing a number of persons and injuring several more. This cooker was a cylinder, 24 feet long by 8 feet in diameter, and had flanged and dished heads. The thickness of the shell of the cylinder was ½ inch and the original nominal thickness of the plates from which the flanged and dished heads were made was ⅝ inch. All joints were double riveted, and all the material and workmanship, except the heads, appeared to be first-class in every particular. In the operation of the cooker it was supposed to be subjected eight or ten times daily to alternations of partial vacuum and 70 pounds steam pressure. As there was no safety valve on the cooker, it might possibly have been subjected at times to th efull boiler pressure of 115 pounds.

The cooker failed without previously observed leak or warning. One head was blown out, the line of fracture being entirely confined to the knuckle of the flange. The cooker had only been in service about a year and was in excellent preservation, inside and out. An examination of the head which failed, as well as of that which remained intact, showed in each head a well-defined groove all the way around the inside of the knuckle. This groove, which was made either by the corner of the die in spinning up the flange, or, as was much more probable, by the use of the fuller and sledge, after the flange had been spun partly up, was about 1¼ inches in width and nearly ⅛ inch deep. To break a wire one first nicks it and then bends it back and forth. The groove in the knuckle of the flange served in this case as a nick, and the alternations of pressure and vacuum did the bending—and the rest.

As in line with the rupture of the cooker may be mentioned the behavior of a certain large copper still, though fortunately this has not so far caused disaster by its failure. The still was originally a vertical cylinder 16 feet in diameter and 12 feet high, with flanged and dished heads. Its workmanship and material were of the very best and the thickness of the copper was ample for the maximum legitimate strains for which it was built. The still was subjected in operation to alternations of vacuum and low pressure. When under pressure the whole structure would rise several inches clear of its concave foundation at the outer edge, resting at such times only on the center of the bottom head. When the pressure was changed to vacuum the still would settle down and its weight would be carried more near the edge than in the center of the foundation. This constant bending back and forth, which was largely concentrated at the knuckle, made it impossible to keep a tight joint between head and shell, besides which, the copper head was beginning to crack at the knuckle. Unable to see any other way out of their difficulty, those in authority reduced the diameter from 16 feet to 15 feet, with consequent loss of capacity and no very great reduction in the risk of fatal accidents.

The still and the cooker above described are, of course, somewhat extreme cases of the dangers of large flanged and dished heads, but it is such extreme cases that always serve to point out defects and to bring about reforms. So long as flanged and dished heads were of comparatively small size their use gave cause for no complaint and developed no weak points in them. The obvious lesson to be drawn from the cases cited is that the flanged and dished head is not well suited for use in large vessels subjected to repeated variations of pressure. The shape of the head, and its method of construction, are such that it will change its form under varying pressure, and each such change of form results in the bending of the head at the knuckle just where it is weakest.

The only figure which does not tend to change its form under internal or external pressure is the sphere. Tanks with flat or conical bottoms are giving place to tanks with spherical bottoms, and spherical cookers are in successful use in paper mills and elsewhere. Had the cooker and still described been built with spherical heads there would have been no need to record the fatalities and loss caused by the failure of the one, nor to dread a similar calamity from the other.—*Engineering Record.*

A meeting of the Master Steam Boiler Makers' Association will be held on Monday evening, May 20, at 8 o'clock, at the Hollenden Hotel, Cleveland, Ohio. This is the evening before the formal opening of the Joint Convention, and President Smythe requests all members of the association to be present if possible.

How to Lay Out a Tubular Boiler.

PART V.

BRACING.

Above the tubes of tubular boilers is a space in the form of the segment of a circle, and this space has to be supported so that it will be safe for the pressure sought. To support this space braces are placed in the boiler. There are several different styles of braces, and among the several styles are a number of patent braces. Braces may be classified into two kinds, direct and indirect.

DIRECT BRACES.

Direct braces are recommended wherever possible, as the brace is allowed its full value per square inch of area. Direct braces are generally called end to end stays or braces. The pressure allowed per square inch of area depends upon the material and manner of making the braces. Braces with welds are not allowed as great a value as braces without welds. Steel braces are allowed a larger stress per square inch than iron braces, as the tensile strength is greater. Different authorities allow different values, so for this reason no set allowance can be stated that will answer for all cases. Iron braces with welds are generally allowed 6,000 pounds per square inch and steel braces without welds 9,000 pounds per square inch. These values will be assumed in our calculations.

The factor of safety of braces is figured higher than the shell, and this runs from 6 to 8, according to different authorities. Some difficulty is experienced in placing the braces so as to support the segment, with as near an equal tension on each brace as possible. It is quite impossible to so arrange the braces that each one will have the same load. Therefore, we must arrange them so that the pressure will be figured on those which carry the greatest pressure.

RELATIONS OF BRACE TO PLATE.

It is an easy matter to figure the pressure a brace will carry when the area that it will have to support is known.

Rule.—Divide the value for the strength of the brace (expressed in pounds) by the area to be supported and the allowable pressure is found.

While the brace may be good for any stated amount the mode of attaching the brace to the plate will have a bearing on the pressure allowable on the plate, as well as having a bearing on the pitch of the stays. Therefore, we must in placing in stays consider the mode of attaching the braces to the plate. It would be possible to have a few large stays whose area was great enough to stand the pressure, but the pitch of the stays might be so great that the pressure could not be allowed on account of the weakness of the plate.

In Figs. 20 and 21 are shown views of a stay which has been threaded and riveted over in the plate. This is regular staybolt practice, and may be found in use in the smaller tubular boilers. The United States rule has two constants—112 for plates lighter than 7/16 inch and 120 for plates heavier than 7/16 inch. As our head is ½ inch we use the constant 120. We desire to find the area that ½-inch plate with screwed stays riveted over will be good for; that is the maximum pitch which can be used for the stays.

Formula:

A = Constant (United States rule 120 for ½-inch plate).
B = Pressure per square inch.
C = Maximum pitch of stays.
D = Thickness of plate in sixteenths of an inch.

$$\sqrt{\frac{A \times D^2}{B}} = C$$

Substituting values we have:

$$\sqrt{\frac{120 \times 64}{175}} = 6.63'' \text{ pitch, or } 6.63 \times 6.63 = 43.9'' \text{ area.}$$

Having found the pitch of the stays and the area that the stay will have to carry we must now determine the size of the stay. Area $\times$ pressure per square inch $=$ total stress upon the stay. Thus $43.9 \times 175 = 7{,}683$ pounds pressure on the plate. Value of stay 6,000 pounds. Thus 7,683 divided by $6{,}000 = 1.2805$ area of stay. We will have to have an area of 1.2805 to support this plate, assuming that the strength of the stay is 6,000 pounds per square inch. This is equal to a fraction less than 1 5/16 inches diameter. These calculations apply to measurements taken at the root of the thread, therefore 1 5/16 inches must not be taken as the diameter of the bolt. Adding on the threads we would for practical purposes use a 1½-inch bolt.

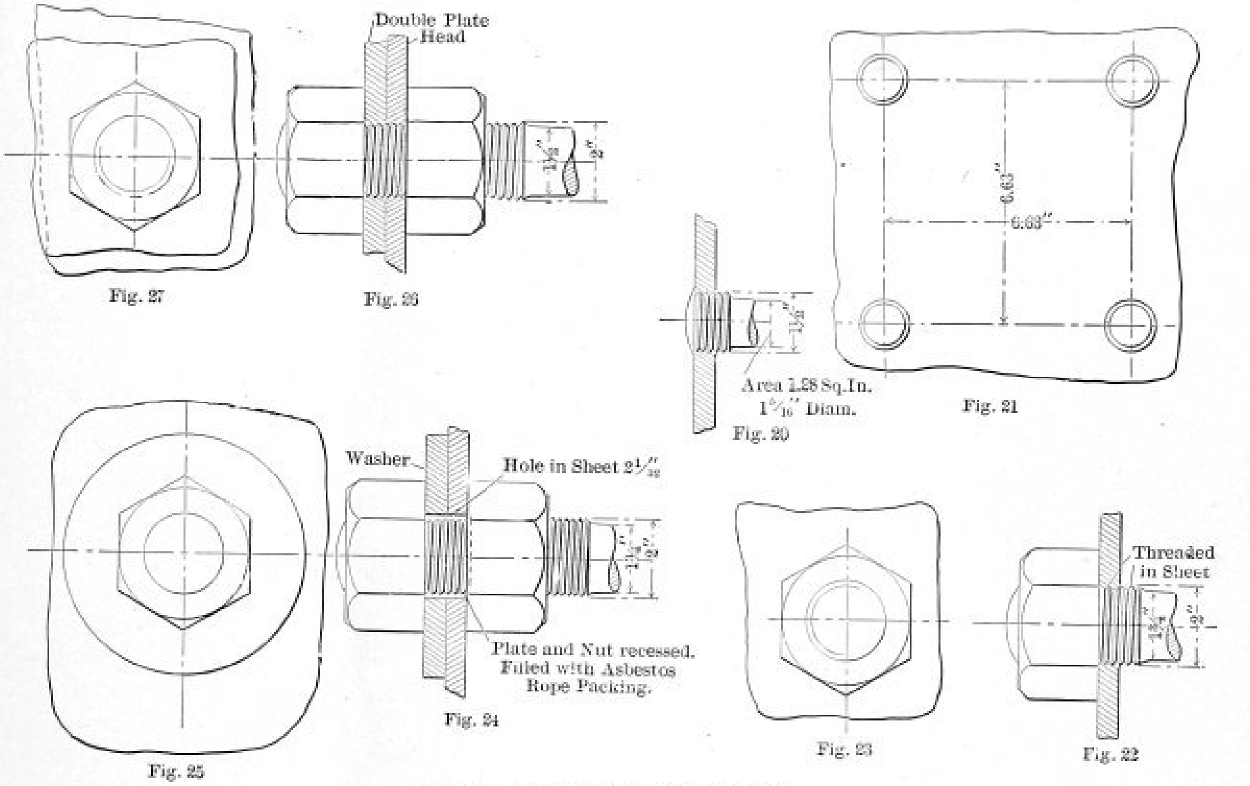
Other rules:

Other authorities allow different values for the strength of a not allow a larger stay, as the plate is the weaker, and nothing would be gained by increasing the size of the stay.

Figs. 20 to 27 inclusive, show four different ways of fastening the braces to the plate. Fig. 21 shows screwed stays riveted over as just worked out in the preceding examples.

Figs. 22 and 23 shows the stay screwed into the plate with a nut on the outside. This nut assists in supporting the plate. so a different constant may be used than with Fig. 21.

Figs. 24 and 25 show a brace with nuts inside and outside, but no thread in the sheet. There is also a washer used on the outside. Stays of this character are generally used where there is difficulty in putting them in or in removing them. The hole in the sheet is made large enough to permit the brace to slide through, the inside nut merely acting to keep the joint. The nut and washer on the outside is a substitute



METHODS OF FASTENING DIRECT STAYS.

stay-bolt as the constant is increased, and also the unit *one* is added to the thickness of the plate.

Formula:

$$\frac{A \times (D + 1)^2}{B} = C$$

Just to show the difference between the two rules let us assume that the stays are 6-inch pitch.

United States Rule:

$$\frac{120 \times 64}{36} = 213 \text{ pounds pressure.}$$

British Columbia rule:

$$\frac{125 \times 81}{36} = 281 \text{ pounds pressure.}$$

It will be understood that while there is a difference in the pressure it only applies to the plate. However, the British Columbia rule would permit of a larger stay, and this would then allow greater pressure, while the United States rule will for the nut and thread in the sheet as in Figs. 23 and 24.

In large boilers of high pressure it is found necessary when using large braces to increase the thickness of the plate where the braces are attached. It may not be necessary for the entire head to be heavier, as the part held by the flues would be thick enough. Therefore, the part to be increased in thickness would be where the stays are spaced with the greatest pitch.

In order for the plates to withstand the pressure a doubling plate is applied, which increases to thickness of the heads at that portion.

Constants:

Figs. 20 and 21—120.
Figs. 22 and 23—140.
Figs. 24 and 25—140.
Figs. 26 and 27—200.

With the constant 140, using the United States rule, the pitch of stays would be as follows:

$$\sqrt{\frac{140 \times 64}{175}} = 7.15'' \text{ pitch.}$$

When a doubling plate is used it is not the practice to figure the entire thickness, including the doubling plate, but to use about 80 percent of this. Thus with ½-inch plate and a ½-inch doubling plate .8, or about 13/16 inch would be used in the United States rule as the thickness of the plate.

Assuming 13/16 inch as the thickness we would have for the pitch

$$\sqrt{\frac{200 \times 169}{175}} = 13.9'' \text{ pitch.}$$

These calculations are based upon the fact that all stays have an equal pitch, but this is not always a feasible arrangement in bracing with end to end stays. Some authorities figure on the maximum pitch regardless of the minimum pitch; thus if the stays were 10 by 12-inch pitch they would figure the area at 12 × 12 inches = 144 square inches. Others square the pitch of stays and square the distance between rows of braces, add the two results together, and then divide this sum by two.

A = Pitch of stays in inches.
B = Distance between rows of stays in inches.
C = Area.

$$\frac{A^2 + B^2}{2} = C$$

After the size and strength of the braces have been found, and the proper thickness of plate and pitch of stays have been

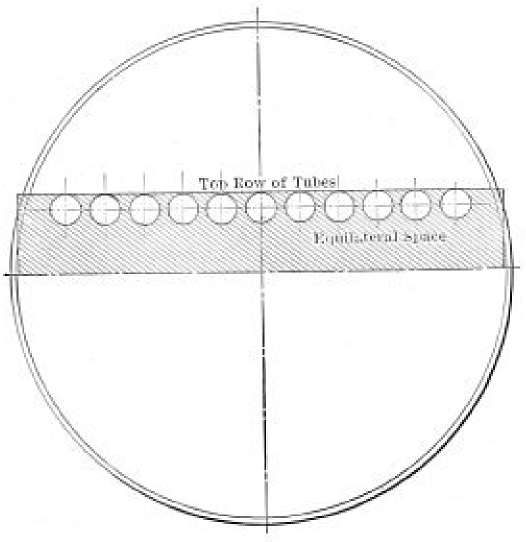


FIG. 28.—SKETCH SKOWING THE EQUIVALENT AREA BRACED BY THE UPPER ROWS OF TUBES.

decided, there is still another matter to consider. It is general practice for the ends of end to end stays to be larger where they are screwed into the sheet. As the smallest diameter must be used as the diameter of the brace, we must be sure to have the diameter at the root of the threads on the upset ends as large or larger than the diameter of the body of the brace. Therefore, the diameter of the upset end depends upon the number of threads per inch.

If United States standard, five threads to the inch are used, the diameter at root of thread would be 1.4902 inches. This is a fraction smaller than the 1½-inch body. Assuming that the brace is good for 9,000 pounds per square inch its total strength would be 13,411.8 pounds.

If twelve threads per inch are used the diameter at the root of the thread would be 1.641 inches and the brace would be good for 14,769 pounds.

Thus, the more threads per inch that are cut the stronger the brace is at the threaded part, since the threads are not as deep.

TO FIND THE AREA OF A SEGMENT.

In this also authorities differ and different results are obtained by using different rules.

Rule 1:

H = Height of the segment in inches.
C = Length of the chord of the segment in inches.
A = Area of the segment in square inches.

Formula:

$$\frac{H^2}{2C} + \frac{2C \times H}{3} = A$$

Assuming that the segment is one-half the head we will figure this rule out. Substituting values we have

$$\frac{27{,}000}{120} + \frac{120 \times 30}{3} = 1{,}425 \text{ square inches.}$$

In order to ascertain just how correct this rule is we will find the area by squaring the diameter and multiplying this product by the constant .7854, which will equal the area for the whole circle. Dividing by 2 will then give the area of the segment.

Example:

$$\frac{60 \times 60 \times .7854}{2} = 1413.72 \text{ square inches.}$$

We find that the two rules are nearly alike, and as the segment to be braced is usually only a small part of the semicircle the difference is yet smaller.

Another rule is to find the area of the semi-circle and to subtract from it the equilateral space. This does not give the exact result, but nearly all rules are sufficiently accurate for the purpose.

SPECIAL NOTE:—The examples given are taken as if the whole segment were being braced. This is done merely to explain the rules clearly.

The Layout of an Offset from a Round to an Oblong Pipe.

The plan and elevation of the offset are shown in Fig. 1.

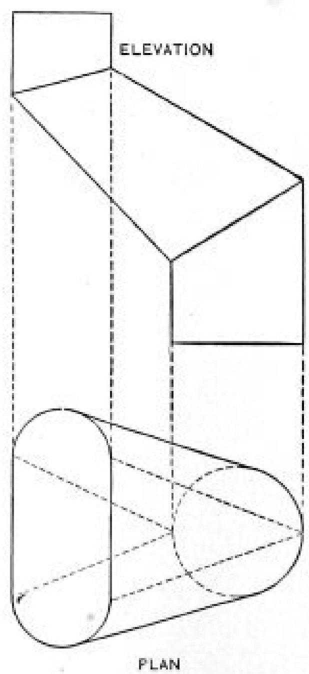


FIG. 1.

It will be seen that this problem requires three separate patterns, and that while two of them may easily be obtained by orthographic projection, the third must be developed by triangulation.

In Fig. 2 is shown the method of solving this problem when both halves are symmetrical. First draw the elevation of the offset as shown by *A B C*. On *C*, place the half-section of the round pipe, as shown in *E*, and on *A* the half section of the oblong pipe, as shown by *D*. Divide the semi-circles in both half-sections into equal spaces, and number *E* from 1 to 5, and *D* from 6 to 12. From these figures in *E* and *D* draw lines parallel to the lines of the pipes intersecting the miter shown from 6' to 12'. Draw the usual measuring lines which are intersected by lines drawn parallel to 6 12 from similar numbered intersections on the miter line between *A* and *B*. Trace the miter cut *H J*; then will *J* 12' 6' *H* be the half pattern for the oblong pipe *A*. For the half pattern for the round pipe *C*, place the girth of the semi-section *E* upon the line 1' 5' extended, as shown by 1 to 5, from which points the usual measuring lines are drawn and intersected by lines drawn parallel to 1' 5' from similar numbered intersections on the miter line between *B* and *C*. Through points thus ob-

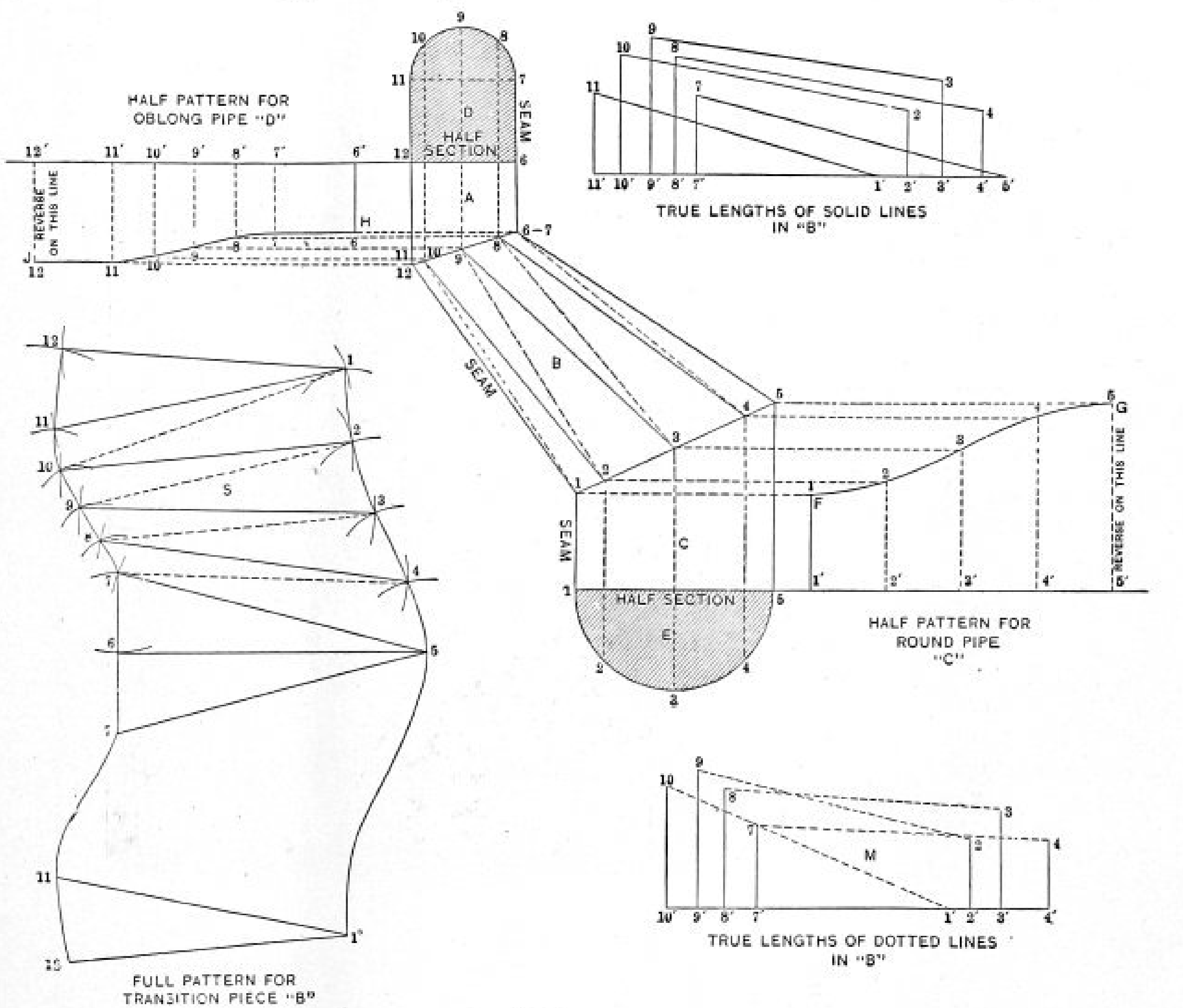


FIG. 2.

lines in *C* and *A*, respectively, as shown from 1 to 5 and 6 to 12 in *B*. Connect these figures with solid and dotted lines, as shown, which represent the bases of sections which will be constructed in *K* and *M*, whose altitudes are equal to the various heights in the semi-sections in *D* and *E*.

For example, to obtain the true length of the line 9-3 in *B*, take this distance and place it on any line in *K*, as shown by 9' 3', from which points erect perpendiculars 9' 9 and 3' 3, equal, respectively, to the distance measured from the line 12 6 to point 9 in *D* and the distance measured from the line 1 5 to point 3 in *E* Then will the distance 9 3 in *K* be the true length of 9 3 in *B*. Proceed in this manner for all the true solid lines shown in *K*, and the true dotted lines shown in *M*, all indicated by similar numbers.

Before the pattern is developed for *B*, the half patterns for *A* and *c* are developed as follows: Obtain the girth of the half section *D* and place it on the line 6' 12, extended as tained trace the miter cut *F G*. Then will *F G* 5' 1' be the required half pattern.

Now, having the true length in the sections *K* and *M* and the true lengths along the miter cuts *G F* and *H J*, the pattern for the transmission piece *B* is developed as follows: Assuming that the seam will come on 1 12 in *B*, take the distance of 5 6 in *B* and place it on the horizontal line 5 6 in *S*. Now, with 6 7 in the half section *D* as a radius and 6 in *S* as a center, describe the arc 7, which is interested by an arc struck from 5 as a center and 5' 7 in *K* as a radius. As the dotted line runs from 7 to 4 in *B*, then take the true lengths of 7 4 in *M*, and with 7 in *S* as a center describe the arc 4, which intersect by an arc struck from 5 as a center and 5 4 in the miter cut *G F* as radius. Now, with 7 8 in the miter, cut *H J* as radius and 7 in *S* as center, describe the arc 8, which intersect by an arc, struck from 4 as center, with the true length 4 8 in *K* as radius. Proceed in this manner using alternately first the division in the miter cut, *F G*, then the true length in *M*; the division in the miter cut *H J*, then the true length in *K* until the line 1 11 in *S* has been obtained. Then with 11 12 in the half-section *D*, or the miter-cut *H J* as radius, and 11 in *S* as center, draw the arc 12, which intersect by another arc struck from 1 as center and 1 12 in *B* as radius. Trace a line through the points thus obtained in *S* as shown by 1, 5, 6, 12, which will be the half pattern. Trace this half pattern opposite the line 5 6, as shown by 5, 1°, 12°, 11°, 7°, 6, and the full pattern is completed.—*The Metal Worker.*.

A Square Fire-Box Marine Boiler.

A wet-back marine boiler, in all respects similar to an ordinary Scotch boiler, with the exception of the furnaces, is a more or less common type found in the boats on the Great Lakes. We present herewith a photograph and the detail drawings of such a boiler recently constructed by the Waterous Engine Works Company, of Brantford, Ontario, Canada.

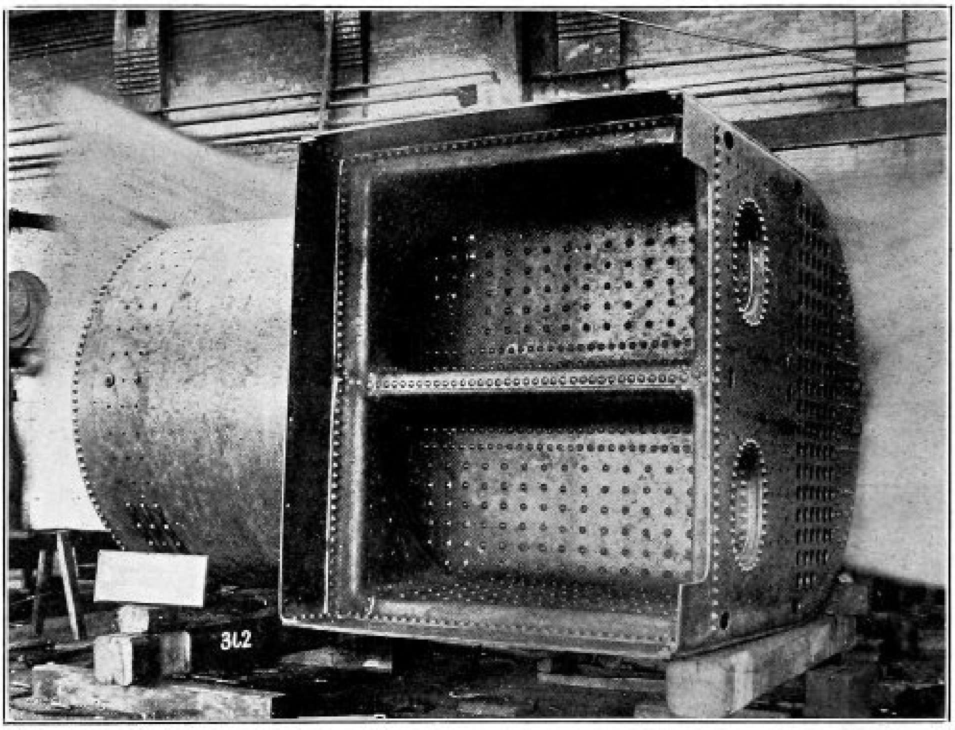


FIG. 1.—A SQUARE FIRE-BOX MARINE BOILER.

The shell of the boiler is 97 inches outside diameter, and is made of 11-16-inch steel plate. The length over all of the boiler is 14 feet, and the height, exclusive of the steam drum, 9 feet 10 inches; including the steam drum, it is 12 feet 10 inches. The boiler has two fire-boxes, from each of which one 24-inch flue and one 10-inch flue lead to a common combustion chamber. From the combustion chamber the gases pass back through the boiler by means of 100 3½-inch tubes.

The furnaces are each 7 feet 6 inches long by 40 inches wide and 43½ inches high, constructed of ⅜-inch plate. The flat sides of the furnaces are stayed by means of 1-inch screw stays, pitched 5⅜ by 5 inches, while the top is supported by sling-stays 2½ by ¾ inches, connected by crowfeet to the shell and crown sheet. The fire-box extends forward, forming what is termed a D flue sheet. The 24-inch and 10-inch flues are lap-welded, made from 5-16-inch stock and are 46½ inches long.

The sides and back of the combustion chamber are stayed with 1-inch screwed stays and the top with 1½-inch screwed stays nutted at the lower end. The segment of the heads above the tubes is stayed by end-to-end stays 1¾ inches in diameter, pitched 10 by 8½ inches. It is further reinforced by ½-inch doubling plates. The flat portion of the wrapper sheet just above the furnaces is stayed by means of two rows of cross-stays made from 2 by ⅝-inch iron bars, fastened at the ends by means of crowfeet.

The steam drum is 24 inches in diameter and 7 feet 6 inches long. The shell is of 5-16-inch plate and the hemispherical heads of ⅜-inch plate. The drum is connected to the shell by a 10-inch flanged pipe.

The heating surface of the tubes is 1,084 square feet; of the furnaces, 200 square feet; of the flues, 66 square feet, and of the combustion chambers, 62 square feet, making a total heating surface of 1,412 square feet. The grate area is 40 square feet, making a ratio of heating surface to grate area of 35.3.

The boiler is designed for a working pressure of 135 pounds per square inch. The longitudinal seams of the shell are double strapped and double riveted with ⅞-inch rivets, spaced 3⅛ inches between centers. The connection from the wrapper sheet to the shell sheet is a double-riveted lap joint. All other end and circumferential seams are single-riveted lap joints.

PERSONAL.

MR. B. F. THROCKMORTON, of Cleveland, Ohio, has accepted a position as layer out with the American Locomotive Company at Scranton, Pa.

MR. E. R. KYLER, foreman of the Davenport Locomotive Company, Davenport, Iowa, has accepted the position as head of the boiler department at the Waterous Engine Works Company, Brantford, Ontario, Canada.

MR. THOMAS ALDCORN, of the Chicago Pneumatic Tool Company, Chicago, Ill., recently made an extended trip through the shipyards of the Pacific Coast in the interests of the above company.

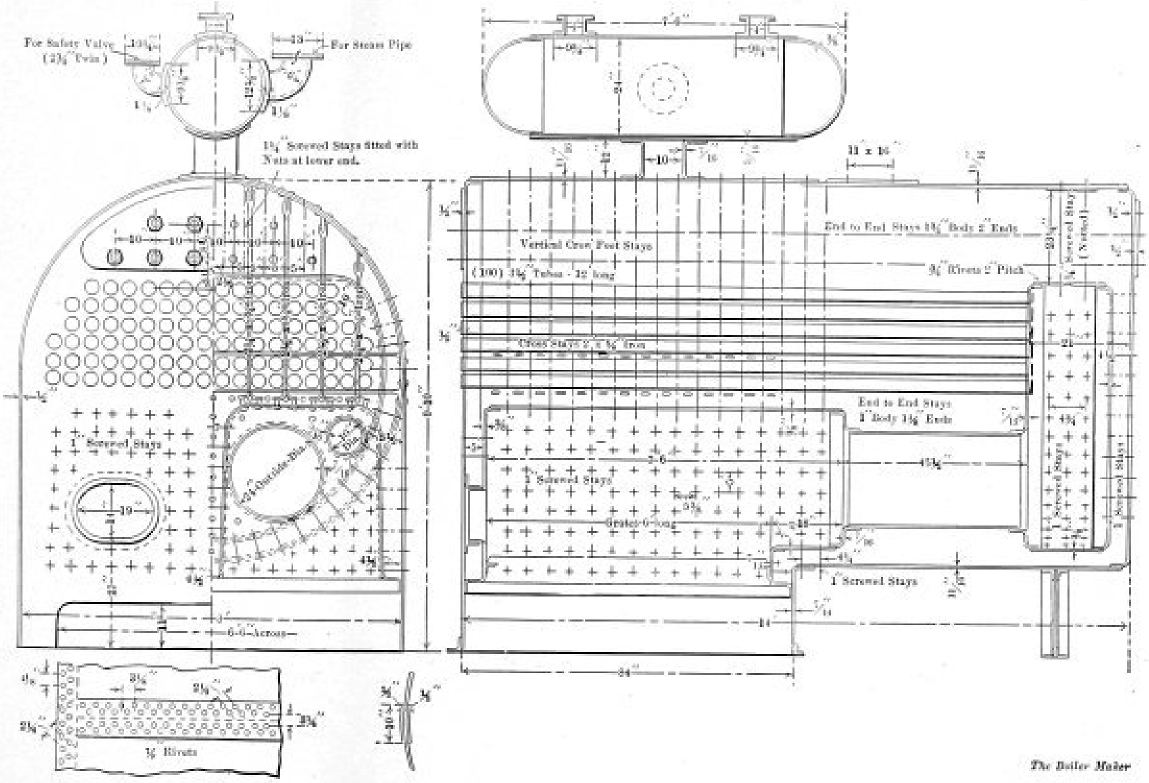


FIG. 2.—DETAIL DRAWINGS OF A SQUARE FIRE-BOX MARINE BOILER.

An Unusual Method for Laying Out an Angle of a Cylinder.

BY J. M. JONES.

The following method for laying out an angle of a cylinder may be interesting to the readers of THE BOILER MAKER, because of its peculiarity.

In Fig. 1 is shown the cylinder, and in Fig. 2 is shown the half pattern laid out by the ordinary means of orthographic projection, that is, one-half the base of the cylinder has been divided into a number of equal parts, and the horizontal line 1-1, Fig. 2, laid out equal in length to one-half the circumference of the base of the cylinder and then divided into the same number of equal parts as the semi-circumference of the cylinder. Vertical lines are then drawn through these points of division, and the corresponding points are projected across from the cylinder, Fig. 1, giving the development of the curved edge of the plate.

In Fig. 3, the same development is obtained, and in a manner which does not require the drawing of Fig. 1. The lower edge of the plate is laid out equal to one-half the circumference of the base of the cylinder and one edge of the plate made equal in height to the distance from the base to the lowest part of the cylinder, and the other edge of the plate made equal in height to the highest part of the cylinder. A vertical and a horizontal line are then drawn through the center of the rectangular figure in which the curve is to be drawn, each half of both of these lines being divided into six equal parts. A distance equal to the diameter of the cylinder times .5708 is then laid off, as shown in Fig. 3, and divided into six equal parts. The dotted lines are then drawn and

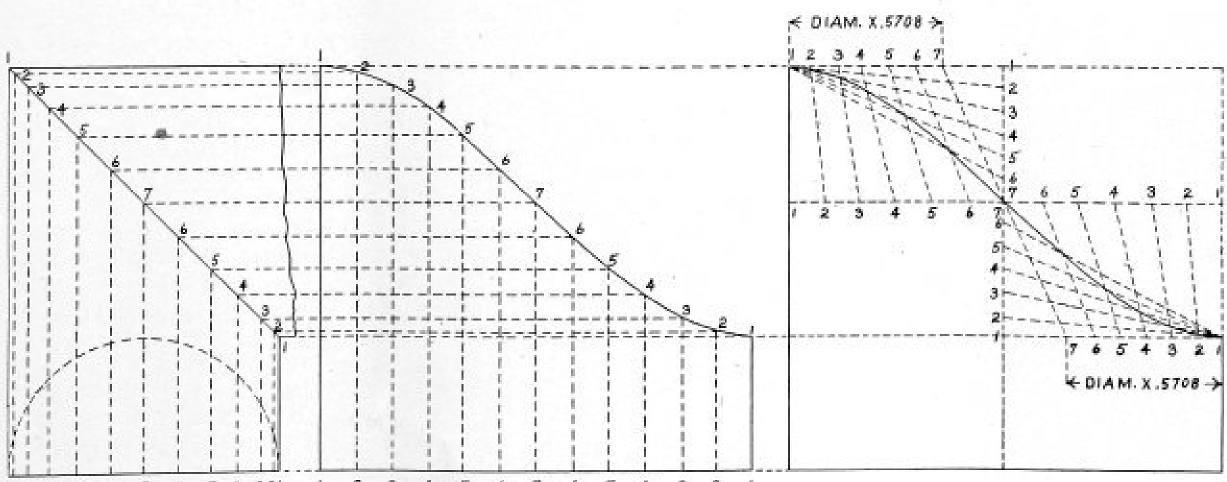


Fig. 1. Fig. 2. Fig. 3.

A DIAGRAM FOR LAYING OUT AN ANGLE OF A CYLINDER.

the points, as determined from the interesction of the lines which are correspondingly numbered, are points on the curve. Drawing the curve through these points gives the layout of the plate, which is identical to that obtained in Fig. 2. Of course, in both Figs. 2 and 3, only the half pattern of the cylinder, is shown.

Calculating Butt-Strapped Boiler Seams.

BY J. E. TERMAN.

In calculating the strength of butt double-strapped joints advantage may be taken of certain short cuts to determine the weakest portion of such joints. This type of joint as usually applied to boiler construction is represented in Figs. 1, 2 and 3 for double, triple and quadruple riveting, respectively.

When it is desired to find the efficiency of a joint like the one indicated in Fig. 3, for instance, the general procedure is: First, calculate the strength of the section of shell between the rivet holes *A* and *B*; second, calculate the strength of the section of shell along *C-D* and add the strength of one rivet in single shear; third, calculate the strength of section of shell along *E-F*, and add the strength of three rivets in single shear; fourth, compute the strength of all rivets in single and double

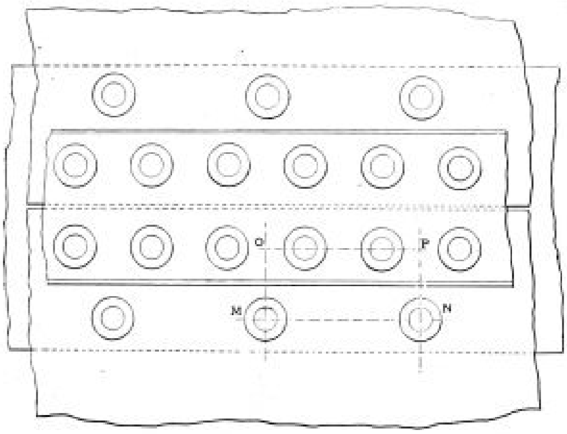


FIG. 1.—DOUBLE-RIVETED JOINT.

shear, respectively, included in the space *AGHB* (the rivets at the lettered points, of course, being considered only as half rivets). The smallest of the above results is then divided by the strength of a section of the shell of a length equal to that of the outer pitch, or the distance from *A* to *B* center to center; this gives the percentage of the strength of the joint as compared with the solid plate.

It will be readily seen that quite an amount of labor is expended in obtaining results that are of no practical value in getting the final results, except that their relative values must be known in order to select the lowest. If this relation between the three values can be ascertained by any simpler means it will lessen the work of determining the final result.

It will be noted that the strength of the section of the shell *C-D*, plus the shearing strength of one rivet, would be exactly equal to the strength of section of shell between the rivet holes *AB*, if the section of metal removed from the plate by a rivet hole were just equal to the shearing strength of a rivet, for this section *C-D* would then be decreased in strength below *A-B* in drilling the extra rivet hole by exactly the same amount added in shearing the rivets in the outer row. With the same relations between the thickness of plate and diameter of rivet holes the strength of section of shell along the section *E-F*, plus the strength of three rivets, would also have the same value as section *A-B*, so that a joint constructed of such proportions between plate and rivet holes would be theoretically as liable to fail along any one of the three sections *A-B*, *C-D*, *E-F*.

If we assume that the plate is increased in thickness while the rivet holes remain the same, the strength removed from the inner section by drilling the extra rivet holes would not be compensated for by the shearing of the rivets in the outer rows, and the inner section would become the weaker; conversely, if the plate was decreased in thickness, the outer sec-

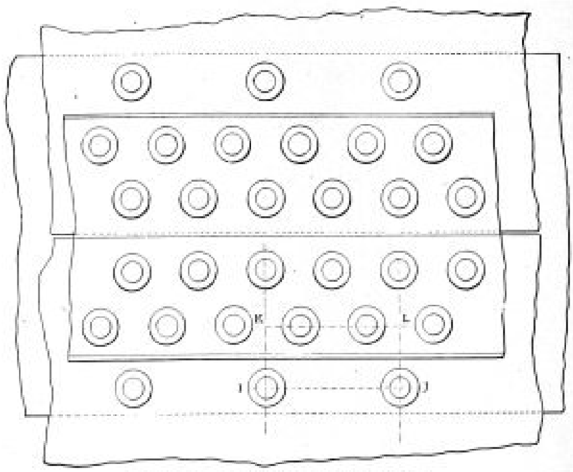


FIG. 2.—TRIPLE-RIVETED JOINT.

tion would be weaker. It is obvious that if one knows whether a plate in a given joint is above or below the thickness that would make that joint equally strong in each of the sections, one can tell whether the weaker section is the outer one or the inner one.

In using this method for calculating a joint we would first find the shearing strength of a rivet, and then multiply the thickness of the shell by its tensile strength and by the diameter of a rivet hole, and if the strength of the rivet were less than the product of these, then the inner section would be the weaker, or otherwise the outer section would be the weaker. If several joints are to be figured, or if joints are frequently figured, a table should be prepared, as below, which gives the

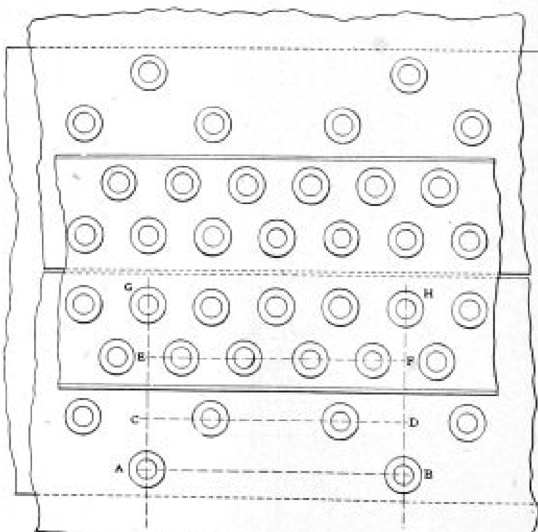


FIG. 3.—QUADRUPLE-RIVETED JOINT.

thickness of plate for various sized rivet holes, at which the joint would be equally as strong at each of the three sections mentioned; the equation for getting these thicknesses would be:

$$\text{Thickness} = \frac{\text{shearing strength of one rivet}}{\text{diameter of rivet hole} \times \text{tensile strength of plate.}}$$

The values assumed in this table are 60,000 pounds tensile strength for plate and 42,000 pounds shearing strength for rivets.

PROPER THICKNESSES OF PLATE TO MAKE RELATIVELY STRONG JOINTS.

Diameter of Rivet Hole. Inches.	Thickness of Plate. Inch.
11/16	0.38
13/16	0.45
15/16	0.515
1 1/16	0.58
1 3/16	0.65

It will be evident that with the aid of such a table it is only necessary to know the thickness of plate and size of rivet hole in a given joint to determine at a glance whether the outer or inner section is the stronger. Of course, where it is necessary to compare the strength of this weaker section with the strength of all the rivets in both single and double shear, their value must be determined in the usual way and compared with the strength of the section previously determined, but for joints constructed like Figs. 2 and 3 it will be found that the strength of the rivets generally exceeds the strength of the solid plate, and unless the joint is of abnormal proportions the strength of the rivets as a whole need not be considered; however, in the double-riveted type of joint, as indicated in Fig. 1, it is well to consider this mode of failure.

It may be well here to point out the fact that in quadruple-riveted joints, as shown in Fig. 3 section *C-D* can never be the weakest of the three, and therefore it need never be considered in making calculations of such joints. The same methods of calculation as outlined above may be used for the double and triple riveted joints, and I am certain that anyone who frequently, or even occasionally, has to compute the strength of such joints will never return to the laborious method of considering the strength of each mode of failure individually after trying this short cut.

There are other methods of failure of joints of this description that have not been considered, because they are not usually taken account of in the calculation of joints already constructed, as the design of such joints is supposed to render other modes of failure than those given improbable.—*Power.*

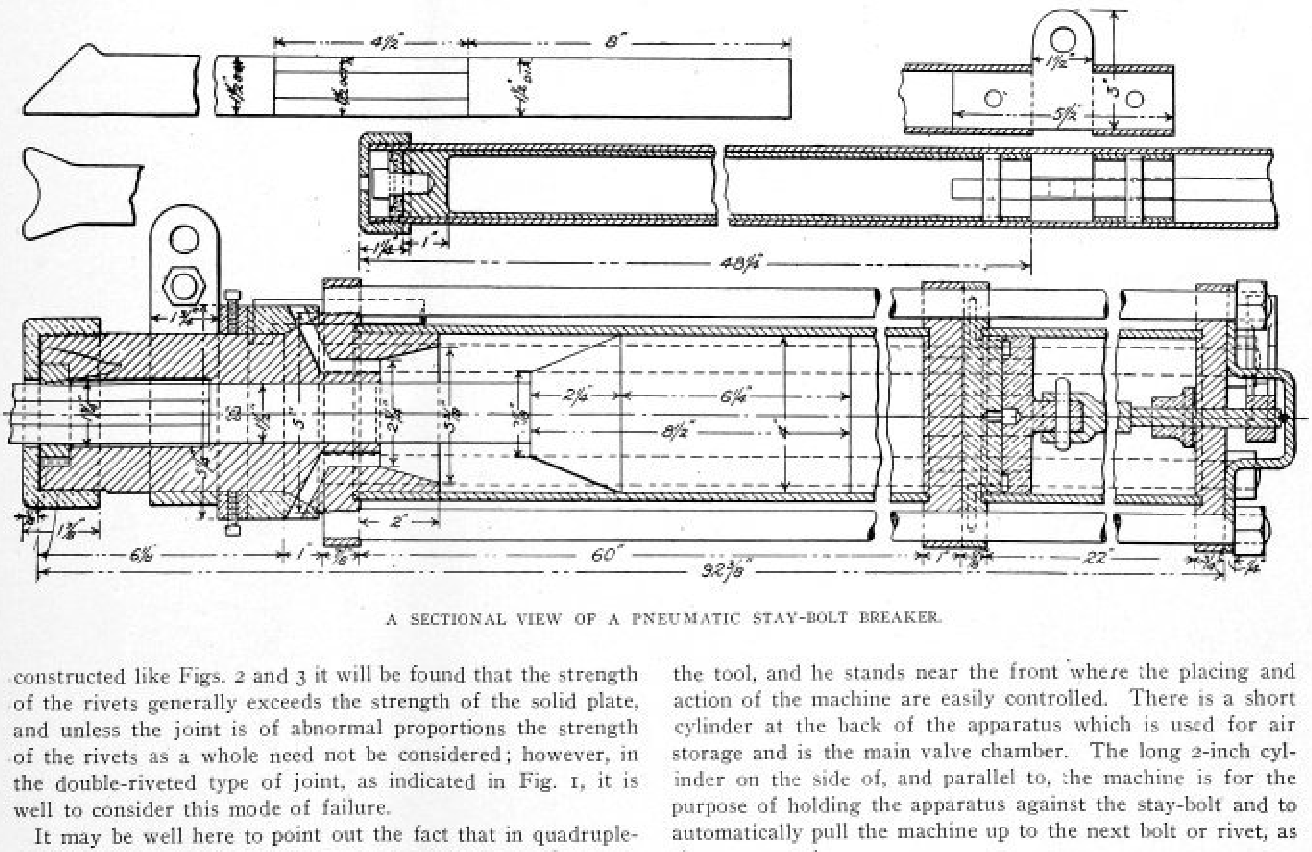
A Staybolt Breaker.

Our engraving shows a stay-bolt breaker operated by compressed air which is used in the Columbus, Ohio, shop of the Hocking Valley Railroad, of which Mr. J. W. Howland is general foreman. The breaker is, roughly speaking, a cylinder something over 7 feet long and about 5¼ inches in diameter. It is suspended by a chain from an overhead crane or other convenient point of support, the clips to which the chain is attached are placed near its ends. The heads of the cylinder are held by six rods outside, screwed into the front head and with nuts on the back head.

The main cylinder is 4 inches in diameter and is fitted with a heavy solid piston which when in motion can strike a very heavy blow. There are six vents at the front end which allow the easy escape of air in front of the piston as it moves forward. The point of the cutting or breaking tool is beveled something like the end of a crowbar and is also slightly curved so that when it is placed against a staybolt it will be driven squarely against it and there will be no chance of a glancing or sidelong blow struck.

The air inlet valves are so placed that one man can operate the tool, and he stands near the front where the placing and action of the machine are easily controlled. There is a short cylinder at the back of the apparatus which is used for air storage and is the main valve chamber. The long 2-inch cylinder on the side of, and parallel to, the machine is for the purpose of holding the apparatus against the stay-bolt and to automatically pull the machine up to the next bolt or rivet, as the case may be.

When the striking piston has delivered its blow and is to be brought back into position, air is introduced in front of it and although some of the air escapes through the tool socket, the pressure is sufficient to carry it back and the hand valve is at once closed. The stay-bolt breaker is a very efficient shop appliance and is spoken of in the highest terms by Mr. W. H. Laughridge, the foreman of the boiler shop. It is a time saver and easily pays for its cost of construction and maintenance.—*Railway and Locomotive Engineering.*



A SECTIONAL VIEW OF A PNEUMATIC STAY-BOLT BREAKER.

A chimney, 506 feet tall, or 46 feet taller than the highest chimney now in existence, is to be built at the Boston & Montana Smelter, Great Falls, Mont.

Elementary Problems in Laying Out.

A NINETY-DEGREE TAPERING ELBOW.

The problems which were published last month gave several methods for laying out conical surfaces where the taper of the cone was so small that the surface could not be developed full size by the usual method of using the slant height of the cone as a radius. These methods may often be applied with slight variation to the development of regular conic surfaces where triangulation is usually employed, thus saving both time and unnecessary labor. A case of this kind is that of the 90-degree elbow shown in Fig. 35, where it is desired to construct an elbow which shall have a regular taper from a section whose diameter is *AC* to a section whose diameter is *GE*. diameter *GE* + ¾ the difference between *AC* and *GE*. With *P* as a center and with this diameter as just computed, draw the arcs *aa*. Similarly the diameter of a cross-section of the cone at the point *I* would be the diameter *GE* + ¼ of the difference between *AC* and *GE*. With *I* as center, and with this diameter draw the arcs *bb*. Then draw the lines *AN* and *CO* from *A* and *C*, respectively, tangent to the arcs *aa*; also draw the lines *NH* and *OJ* tangent to the arcs *aa* and *bb* and the lines *GH* and *EJ* from *G* and *E*, respectively, tangent to the arcs *bb*. Draw *NO* from the intersection of the sides *AN* and *NH* to the intersection of the sides *CO* and *OJ*; likewise draw *HJ* from the intersection of the lines *NH* and *GH* to the intersection of the

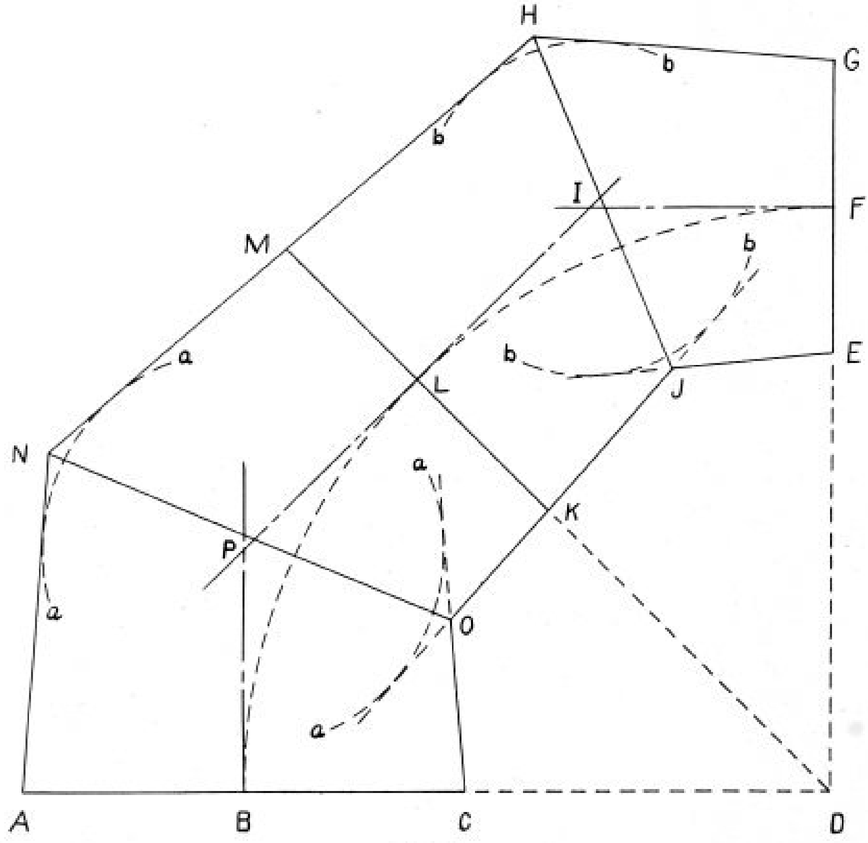


FIG. 35.

It is first necessary to draw a side elevation of this elbow in such a way that the sections will have a regular taper, that is, so that if the separate sections were turned about and placed one on the other, the center lines *BP*, *PI* and *IF* forming one continuous straight line, the resulting figure would be the frustum of a cone. To do this draw the line *AD* and at *D* square up the line *DG* at right angles to *AD*. With *D* as a center, and the trams set to a radius *DB*, strike the arc *BLF*, which curve the elbow is to follow. Divide the quarter circle *BLF* into two equal parts at the point *L*, then draw the line *DL*, and at *L* square up the line *PI* at right angles to *LD*. *PI* will then be tangent to the quarter circle and will be the center line of the middle section of the elbow. At *B* square up the line *BP* at right angles to *AD*, and similarly at *F*, square up the line *FI* at right angles to *DG*. The lines *BP*, *PI* and *IF* are then the center lines of the three sections of the elbow.

To draw the outline of the sections it is necessary to know the diameter of the sections at the points *P* and *I*, which are the intersections of their center lines. Since the taper is regular, and the center section has twice the length of the end sections, the diameter of the cone at the point *P* would be the lines *OJ* and *EJ*. *HJ* and *NO* are then the miter lines of the sections. This completes the side elevation of the elbow.

The elbow is now made up of four similar sections (the center section may be divided into two parts at the line *MK* and each part developed separately). Since the layout of all of these sections is accomplished in a similar manner, using, of course, the proper dimensions for each as determined from the side elevation, we will take up in detail the patterns for only one section; as, for instance, the section *ANOC*. This section is shown at *AFEC*, Fig. 37. Divide the section into two parts by means of the line *BE*, which is parallel to the base *AC*. The section *ABEC* is then the frustum of a right circular cone and may be laid out in the usual manner. Having found the development of the section *ABEC*, the portion *BFE* can be easily added to it. The procedure is as follows:

To lay out the section *ABEC*, Fig. 37, find the circumferences corresponding to the diameters *AC* and *BE*. It will be necessary to lay out only one-half of the pattern, since the two halves are exactly alike. Therefore, in Fig. 36, draw the line *CD* equal to one-half the circumference of the base *AC*, Fig. 37. Also draw the line *AB* equal to one-half the circumference of the base *BE* at a distance from *CD* equal to *AB*, Fig.

37, the slant height of the frustrum. Draw the lines AC and BD and then from O, the center of CD, square up the line OP at right angles to AC. Bisect the angle COP with the line OS. Then the distance SC measured along the line AC is the camber of the sheet. Lay off OX equal to SC. Divide the lines CD and AB each into 8 equal parts and draw the dotted lines, as shown, through the corresponding points in each base. Divide the distance OX by 16 and multiply the quotient by 7, 12 and 15, respectively, giving the camber to be laid out on each of these dotted lines. Having determined the curve CXD at the lower edge of the plate, set the trams to the distance AC, the width of the plate, and lay off this distance along each of the dotted lines from the curve CD, locating the upper edge of the plate $A4B$. Make the length of the curves CXD and $A4B$ correspond exactly to the semi-circumferences of the bases AC and BE, respectively, Fig. 37.

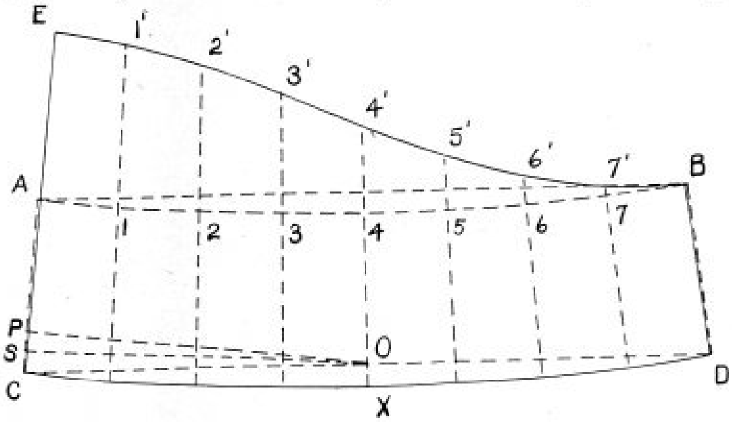


FIG. 36.

Returning to Fig. 37, draw a half-plan view of the bases AC and BE. Divide the semi-circumference of each into the same number of equal parts into which the lines CD and AB, Fig. 36 were divided. Project these points of division to the lines AC and BE and through the corresponding points on these two lines draw the dotted lines as indicated, producing them to intersect the line FE. It will be seen that we now have drawn on the side elevation of the section the equally spaced lines which have been drawn in the pattern and it is only necessary to lay off along these lines in the pattern the distances as measured from the cross-section BE to the miter line FE in the side elevation. Since this is the side elevation of a cone, the points at which these lines intersect the miter line should be projected across to the line AF in order that their true lengths may be measured. Then lay off 1 1', 2 2', 3 3', etc., in the pattern equal, respectively, to the distances $B1$, $B2$, $B3$, etc., as measured from Fig. 37. Draw a smooth curve through the points E, 1', 2', 3', 4', 5', 6', 7', B and the half pattern for the section is complete.

The sections $MKON$, $MKJH$ and $GEJH$ may be laid out in the same manner. Care should be taken to make the proper allowances in the length of the plates which form inside and outside rings. The laps must also be added to the pattern shown in Fig. 36.

The use of special steels for rivets was the subject of a communication to the Paris Academy of Sciences lately by M. G. Charpy. A systematic study of the thermal and mechanical properties of various alloys of steel has led to the use of a chrome nickel steel for rivets, the strength of which is 2.5 times that of the metal usually employed for this purpose, and this without the need of any special precautions in practical use.

Rules and Regulations Prescribed by the British Board of Trade for the Inspection and Construction of Steam Boilers.

Surveyors are required to fix the limits of weight to be placed on the safety valves of passenger steamships and to determine whether the boiler and machinery are sufficient for the service intended and in good condition.

Working Pressure.—The surveyor should fix the working pressure for boilers by a series of calculations of the strength of the various parts, and according to the workmanship and material. The Board of Trade have arranged to receive, for examination by their surveyors, plans and particulars of boilers before the commencement of manufacture, by these means hoping to prevent questions arising after the boilers are finished and on board. This practice has been found to work well in

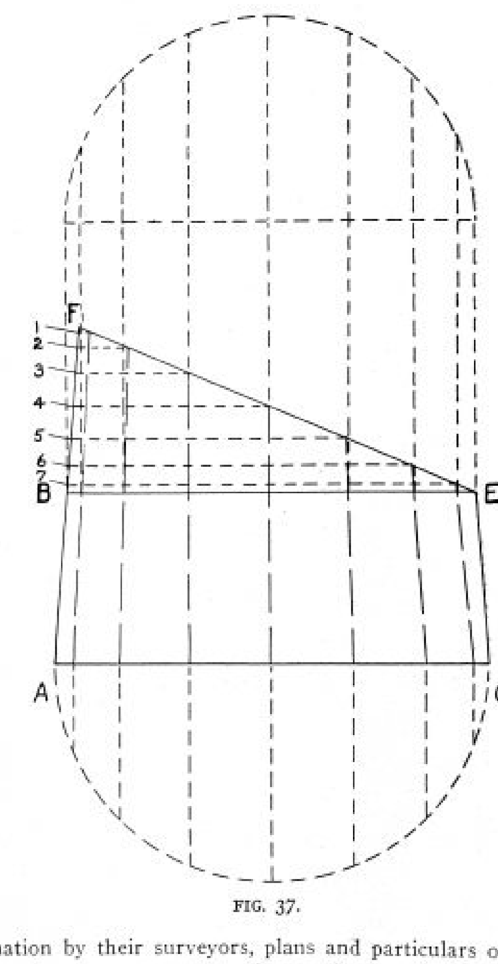


FIG. 37.

saving time to the surveyors, and in preventing expense, inconvenience, and delay to owners. The senior engineer surveyors should therefore receive and report on any plans of boilers intended for passenger vessels that may be submitted in due course. When the surveyor has received plans and tracings of new boilers, or of alterations to boilers, and has approved of them, he will, of course, be careful in making his examination from time to time to see that they are followed in construction. When he has not had the plans submitted, but is called in to survey a boiler, he will measure the parts, note the details of construction, and, if necessary, bore the plates to ascertain their thickness, etc., before he gives his declaration. And in the event of any novelty in construction, or of any departure from the practice of staying and strengthening noted in these regulations, or of the boiler being made of steel, he should report full particulars to the Board of Trade before fixing the working pressure.

The thickness of plates used in the construction of boilers should not be less than 5-16 inch.

The surveyor cannot declare a boiler to be safe unless he is fully informed as to its construction, material, and workmanship. He should, therefore, be very careful how he ventures to give a declaration for a boiler that he is not called in to survey until after it is completed, and fixed in the ship.

IRON BOILERS.

Stays.—In the case of new boilers the surveyor may allow a stress not exceeding 7,000 pounds per square inch of net section on solid iron screwed stays supporting flat surfaces, but the stress should not exceed 5,000 pounds when the stays have been welded.

A stress of 6,000 pounds may be allowed on the net section of iron stay-tubes, providing that the net thickness is in no case less than ¼ inch.

When the threads of longitudinal stays are finer than six per inch, the depth of the external nuts should be at least one and a quarter times the diameter of the stay.

The areas of diagonal stays are found in the following way: Find the area of a direct stay needed to support the surface, multiply this area by the length of the diagonal stay and divide the product by the length of a line drawn at right angles to the surface supported to the end of the diagonal stay; the quotient will be the area of the diagonal stay required.

When gusset stays are used, their area should be in excess of that found in the above way.

When the tops of combustion boxes or other parts of a boiler are supported by solid girders of rectangular section, the following formula should be used for finding the working pressure to be allowed for the girders, assuming that they are not subjected to a greater temperature than the ordinary heat of steam, and in the case of combustion chambers that the ends are properly bedded to the edges of the tube plate and the back plate of the combustion box:

$$\frac{C \times d^2 \times T}{(W - P)\, D \times L} = \text{working pressure.}$$

W = width of combustion box in inches.
P = pitch of supporting bolts in inches.
D = distance between the girders from center to center in inches.
L = length of girder in feet.
d = depth of girder in inches.
T = thickness of girder in inches.
N = number of supporting bolts.

$$C = \frac{N \times 1200}{N + 1} \text{ when the number of bolts is odd.}$$

$$C = \frac{(N + 1)\, 1200}{N + 2} \text{ when the number of bolts is even.}$$

The working pressure for the supporting bolts and for the plate between them should be determined by the rules for ordinary stays and plates.

Flat Surfaces of Boilers.—The pressure on plates forming flat surfaces is found by the following formula:

$$\frac{C \times (T + 1)^2}{S - 6} = \text{working pressure.}$$

T = thickness of the plate in sixteenths of an inch.
S = surface supported in square inches.
C = constant according to the following circumstances:
C = 192 when the plates are not exposed to the impact of heat or flame, and the stays are fitted with nuts on both sides of the plates, and doubling strips not less in width than two-thirds the pitch of the stays and of the thickness of the plates, are securely riveted to the outside of the plates they cover.
C = 168 when the plates are not exposed to the impact of heat or flame, and the stays are fitted with nuts on both sides of the plates, and with washers not less in diameter than two-thirds the pitch of the stays and of the same thickness as the plates, securely riveted to the outside of the plates they cover.
C = 132 when the plates are not exposed to the impact of heat or flame, and the stays are fitted with nuts on both sides of the plates, and with washers outside the plates at least three times the diameter of the stay, and two-thirds the thickness of the plates they cover.
C = 120 when the plates are not exposed to the impact of heat or flame and the stays are fitted with nuts on both sides of the plates.
C = 90 when tube plates are not exposed to the direct impact of heat or flame, and the stays are fitted with nuts.
C = 70 when tube plates are not exposed to the direct impact of heat or flame and the stay-tubes are screwed and expanded.
C = 70 when the plates are not exposed to the impact of heat or flame, and the stays are screwed into the plates and riveted over.
C = 60 when the plates are exposed to the impact of heat or flame, with steam in contact with the plates, and the stays fitted with nuts and washers, the latter being at least three times the diameter of the stay, and two-thirds the thickness of the plates they cover.
C = 54 when the places are exposed to the impact of heat or flame, with steam in contact with the plates, and the stays fitted with nuts only.
C = 80 when the plates are exposed to the impact of heat or flame, with water in contact with the plates, and the stays screwed into the plates and fitted with nuts.
C = 60 when the plates are exposed to the impact of heat or flame, with water in contact with the plates, and the stays screwed into the plates, and having the ends riveted over to form substantial heads.
C = 36 when the plates are exposed to the impact of heat or flame, with steam in contact with the plates, with the stays screwed into the plates, and having the ends riveted over to form substantial heads.

When the plates are not exposed to the impact of heat or flame and doubling plates covering the whole of the flat surfaces are riveted to the plates, the working pressure may be found by the following formula:

$$\frac{C\,(T + 1)^2 + C\,(T_1 + 1)^2}{S - 6} = \text{working pressure.}$$

T = thickness of the plate in sixteenths of an inch.

T_1 = thickness of the doubling plate in sixteenths of an inch.
S = surface supported in square inches.
C = constant applicable to the case as given above.

When doubling plates do not cover the whole of the flat surfaces, but are fitted between the rows of supporting stays the strength allowed for them should be two-thirds only of that which would be allowed for similar doubling plates extending beyond and embracing the supporting stays.

In calculating the working pressure of the portion of tube plates between the boxes of tubes, the value of S in the above formula should be found as follows:

$$\frac{D^2 + d^2}{2} = S$$

Where D = the horizontal pitch of the stay-tubes in inches, and d = the vertical pitch of the stay-tubes in inches.

The pitches should be measured from center to center of the stay-tubes and no deduction should be made for any tubes in the contained surface.

In the body of tube plates the value of S may be found in the ordinary way and the area of the tubes in the space bounded by the stay-tubes may be deducted.

In cases where plates are stiffened by T or angle irons, and a greater pressure is required for the plates than is allowed by the use of the above constants, the case should be submitted for the consideration of the Board of Trade.

When a circular flat end is bolted or riveted to an outside ring or flange of a cylindrical shell, S in the formula may be taken as the area of the square inscribed in the circle passing through the centers of the bolts or rivets securing the end, provided the ring or flange is of sufficient thickness.

When the riveted ends of screwed stays are much worn, or when the nuts are burned, the constants should be reduced, but the surveyor must act according to the circumstances that present themselves at the time of the survey, and it is expected that in cases where the riveted ends of screwed stays in the combustion boxes and furnaces are found in this state it will be often necessary to reduce the constant 60 to about 36.

Compressive Stress on Tube Plates.—The surveyors should not, in any case, allow a greater compressive stress on the tube plates than 11,000 pounds, which is that used in the following formula:

$$\frac{(D - d)\ T \times 22{,}000}{W \times D.} = \text{working pressure.}$$

D = least horizontal distance between centers of tubes in inches.
d = inside diameter of ordinary tubes in inches.
T = thickness of tube plate in inches.
W = width of combustion box in inches between the tube plate and back of fire-box, or distance between the combustion box tube plates when the boiler is double ended and the box common to the furnaces at both ends.

Having regard to many cases in which serious defects have been discovered, the surveyors should take care that wet-bottomed and other boilers, the outside of the bottom of which cannot be seen, are lifted for inspection at least once in every four years, or oftener if the surveyors consider it necessary. It will often be found necessary long before this to reduce the pressure, unless the boilers are lifted from their seats to enable the surveyors to judge of their efficiency. If the owners in any special case have any good reasons for not wishing to lift them when the surveyor requires it, the surveyor should submit the whole case in detail to the Board of Trade for their consideration.

The surveyor should record in the hydraulic test book the dates on which boilers which have been lifted are inspected, and whether the boilers were out of the ship when examined, and if out of the ship where they were examined. Boilers which have been lifted should in all cases be subjected to the hydraulic test before they are reset.

Cylindrical Boilers.—The Board of Trade consider that boilers well constructed, well designed, and made of good material should be allowed an advantage in the matter of working pressure over boilers inferior in any of the above respects, as unless this is done the superior boiler is placed at a disadvantage, and good workmanship and material will be discouraged. They have, therefore, caused the following rules to be prepared:

Factor of Safety.—When the cylindrical shells of boilers are made of the best material, with all the rivet holes drilled in place and all the seams fitted with double butt straps, each of at least five-eighths the thickness of the plates they cover, and all the seams at least double riveted, with rivets having an allowance of not more than 75 percent over the single shear, and provided that the boilers have been open to inspection during the whole period of construction, then 5 may be used as the factor of safety. The tensile strength of the iron is to be taken as equal to 47,000 pounds per square inch with the grain, and 40,000 pounds across the grain. If, however, the iron be tested and the elongation measured in a length of 10 inches is not less than 14 percent with, and 8 percent across the grain, and the surveyors are otherwise satisfied as to the quality of the plates and rivets, 4.5 may be used as the factor of safety instead of 5, in which case the minimum actual tensile strength of the plates should be used in calculating the working pressure.

When the above conditions are not complied with, the additions in the following scale should be made to the factor of safety, according to the circumstances of each case:

†A = .15—To be added when all the holes are fair and good in the longitudinal seams, but drilled out of place after bending.
†B = .3 —To be added when all the holes are fair and good in the longitudinal seams, but drilled before bending.
C = .3 —To be added when all the holes are fair and good in the longitudinal seams, but punched after bending
D = .5 —To be added when all the holes are fair and good in the longitudinal seams, but punched before bending.
*E = .75—To be added when all the holes are not fair and good in the longitudinal seams.
F = .1 —To be added if the holes are all fair and good in the circumferential seams, but drilled out of place after bending.
†G = .15—To be added if the holes are fair and good in the circumferential seams, but drilled before bending.
H = .15—To be added if the holes are fair and good in the circumferential seams, but punched after bending.
†I = .2 —To be added if the holes are fair and good in the circumferential seams, but punched before bending.
*J = .2 —To be added if the holes are not fair and good in the circumferential seams.
K = .2 —To be added if double butt straps are not fitted to the longitudinal seams, and the said seams are lap and double riveted.
L = .1 —To be added if double butt straps are not fitted to the longitudinal seams, and the said seams are lap and treble riveted.
M = .3 —To be added if only single butt straps are fitted to the longitudinal seams, and the said seams are double riveted.
N = .15—To be added if only single butt straps are fitted to the longitudinal seams, and the said seams are treble riveted.
O = 1.0 —To be added when any description of joint in the longitudinal seams is single riveted.
P = .1 —To be added if the circumferential seams are fitted with single butt straps and are double riveted.
Q = .2 —To be added if the circumferential seams are fitted with single butt straps and are single riveted.
R = .1 —To be added if the circumferential seams are fitted with double butt straps and are single riveted.
†S = .1 —To be added if the circumferential seams are lap and are double riveted.
T = .2 —To be added if the circumferential seams are lap and are single riveted.

U = .25—To be added when the circumferential seams are lap and the strakes of plates are not entirely under or over.

‡V = .3 —To be added when the boiler is of such a length as to fire from both ends, or is of unusual length, as in the case of flue boilers and the circumferential seams fitted as described opposite P, R, and S, but, when the circumferential seams are as described opposite Q and T, V = .4 should be added.

*W = .4 —To be added if the longitudinal seams are not properly crossed.

*X = .4 —To be added when the iron is in any way doubtful, and the surveyor is not satisfied that it is of the best quality.

††Y = 1.65—To be added if the boiler is not open to inspection during the whole period of its construction.

When marked * the factor may be increased still further if the workmanship or material is such as in the surveyor's judgment renders such increase necessary.

† When the holes are to be reamed or bored out in place, the case should be submitted to the board as to the reduction or omission of *A*, *B*, *G*, and *I*, as heretofore.

‡ When the middle circumferential seams are double strapped and double riveted or lap and treble riveted, and the calculated strength not less than 65 percent of the solid plate *S* (.1) and *V* (.3) may be omitted. The end circumferential seams in such cases should be at least double riveted.

†† When surveying boilers that have not been open to inspection during construction, the case should be submitted to the board as to the factors to be used.

Formulæ for ordinary chain-riveted and ordinary zig-zag riveted joints, and for joints of these descriptions, when every alternate rivet in the outer or in the outer and inner rows has been omitted:

Let E = distance from edge of plate to center of rivet in inches.

V = distance between rows of rivets in inches.

V_1 = distance between inner and middle row of rivets in inches for joints *J*. and *K*.

B = boiler pressure in pounds per square inch.

C = 1 for lap or single-butt joints.

C = 1.75 for double-butt joints.

d = diameter of rivets in inches.

D = inside diameter of boiler in inches.

F = factor of safety for shell plates.

n = number of rivets in one pitch.

P_D = diagonal pitch in inches between inner and middle rows of rivets in inches for joint *J*.

p_D = diagonal pitch in inches.

p = greatest pitch of rivets in inches.

r = percentage of plate left between holes in greatest pitch.

R = percentage of value of rivet section.

R_1 = percentage of combined plate and rivet section.

S = tensile strength of material in pounds per square inch of section.

S_1 = tensile strength of plate in tons.

T = thickness of plate in inches.

T_1 = thickness of each butt strap in inches.

% = least value of r, R, R_1 as the case may be, divided by 100.

When joints are used in boiler construction other than those shown in the attached sketches, or when any of the rivets are pitched less than two diameters apart, the particulars of such joints should be submitted for the consideration of the board.

Ordinary Chain and Zig-Zag Riveted Joints.

Iron plates and iron rivets or steel plates and steel rivets:

$$\frac{100\,(p - d)}{p} = r$$

(*To be continued.*)

The Joint Convention.

The joint convention of the M. S. B. M. A. and I. R. M. B. M. A. will be formally opened at 10 o'clock Tuesday morning, May 21, at the Hollenden Hotel, Cleveland, Ohio, the opening exercises being conducted by the Rev. Charles P. Mitchell. An address of welcome will be delivered by the Hon. Tom L. Johnson, Mayor of Cleveland. Following this, there will be addresses by Mr. J. F. Deems, S. M. P. & R. S., New York Central lines; Mr. Harry D. Vought, an expert railroad club secretary; President Smythe, of the Master Steam Boiler Makers' Association, and President Hempel, of the International Railway Master Boiler Makers' Association. Tuesday afternoon will be devoted to a visit to the L. S. & M. S. Collingwood shops. The entire day, Wednesday, the 22d, will be devoted to a discussion of the papers which have been prepared for this meeting. Advance papers in printed form will be in the hands of all members thirty days before the convention. Thursday morning, May 23, will be taken up with an open discussion of shop practices. All memoranda to be discussed at this time must be in the hands of the presiding officer before the close of the second day's session. Thursday afternoon will be given up to the affairs of the association, reports of committees, election of officers, etc.

In addition to the above program a meeting of the Master Steam Boiler Makers' Association will be held at 8 o'clock, Monday evening, May 20.

Mr. George Slate, secretary of the Boiler Makers Supply Men's Association, announces that a meeting of that organization will be held in the rooms of the secretary at the Hollenden Hotel, Cleveland, O., at 11:00 o'clock, Tuesday morning, May 21.

Boiler Setting for the Smokeless Combustion of Bituminous Coal.

Mr. A. Bement, of Chicago, Ill., in a paper recently presented at a meeting of the American Society of Mechanical Engineers, describes an improved form of boiler setting for the smokeless combustion of bituminous coal, no features of which are patented, and which every steam-plant owner, consulting engineer or architect is free to install upon its merits.

Fig. 1 shows an elevation and section of a modified design of a boiler equipped with a chain-grate stoker, although any other mechanical stoker would be applicable. The principal objects to be secured in this design are: the attainment of a perfect and smokeless combustion and the full utilization of the boiler heating surface.

The first requirement is secured by the location of a tile furnace roof, which is supported by the boiler tubes of the lower row. The individual refractory tiles used in the formation of this roof are illustrated in detail in Fig. 2, and by a vertical cross-section, Fig. 3. The effect of the presence of this tile roof is to prevent the flow of unburned gases among the tube surfaces of the boiler, and to insure that they travel a considerable distance before the heating surface is reached, during which time these gases and the air present therewith may become sufficiently mixed together to insure entire combustion. The particular form of stoker shown, that of the chain grate, owing to the fact that the fuel is fed only in a horizontal line, and for which reason sudden and irregular charges of fuel cannot enter the fire, insures the apparatus to be entirely smokeless. When other styles of mechanical stokers are used under such roof, the attainment of complete combustion is dependent upon careful manipulation of the machine and fire, because the capacity of the tile roof furnace herewith illustrated is only sufficient to properly mix together the air and gases which flow from a chain-grate fire. Therefore, in other forms of stokers, it is necessary for the uniformity in feed of coal and condition of fire to be equal to that secured with chain grates, for complete combustion to be effected. A considerable number of such tile-roof furnaces are now in successful operation.

To insure that all of the boiler surface shall be usefully employed the gases are led over the whole portion of it by means of passages of less area than are commonly used. It is the writer's observation that in many boilers various corners and other portions are not acted upon by hot gases, because the decreasing volume due to the gases becoming cooled is not equal to the capacity of the passage, for which reason in this design the additional baffles are employed. The decrease in size of these passages, however, is not in the same ratio as the reduction in volume of gas. Proportioning the passages according to the volume of the gases in the different parts of the boiler would have required at the inlet to the tube surface a space much larger, with the effect of very materially reducing the length of the tile roof. Therefore the compromise illustrated is adopted.

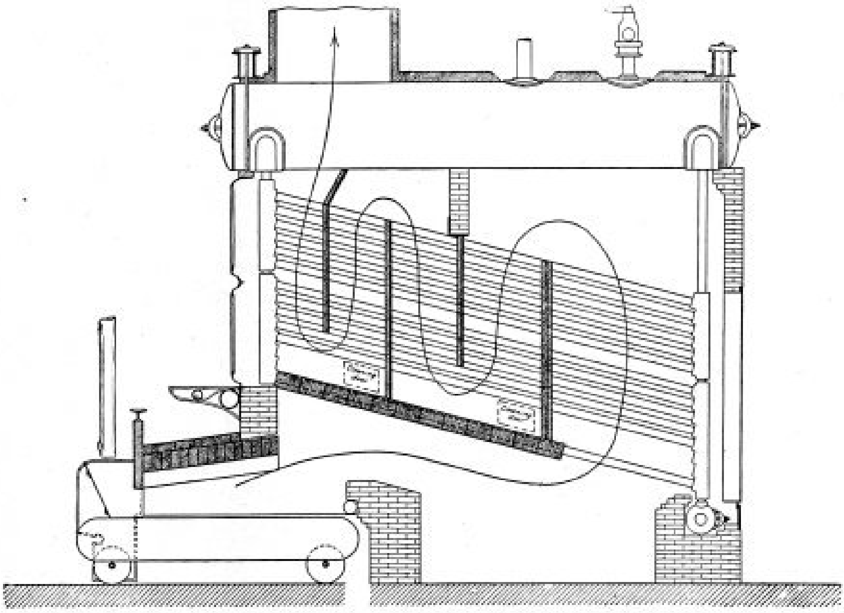


FIG. 1.

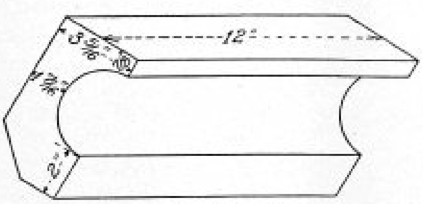


FIG. 2.

A space at the bottom of the boiler above the tile roof equal to that which would ordinarily be required by the second and third tier of tubes, is left vacant for the purpose of accumulating dust, which may be removed through cleaning down in the side wall of the setting. The lower tubes supporting the tile roof are of 3.5 inches diameter, and of a heavier gage than the 4-inch tubes above. The smaller diameter is employed for the purpose of affording greater space for the necks of the tiles than is obtainable with the 4-inch tubes.

The contracted passages among the tube surface of this boiler necessarily produce a high resistance, and for this reason a strong draft is required, and this appears to be true of any boiler when arranged so that all of the heating surface is utilized. According to the author's present conclusions, a combination of forced and induced draft affords means for the production of the best obtainable combustion, particularly so with the chain-grate stoker. The office of the forced draft is to move the gases as far as the furnace chamber, from which point they flow among the heating surfaces of the boiler to the chimney by means of the power of induced draft. Therefore, the influence of the forced draft extends from below the grate to the furnace chamber, while the power of the induced draft extends from the chimney among the heating surfaces to the point in the furnace, at which that of the forced draft ceases. Under such conditions the pressure of the gases in the furnace is the same as that of the atmosphere. This prevents a portion of the air leakage, which, under other conditions, would flow into the furnace chamber by way of openings at the stoker through the brick walls and elsewhere. By manipulating the intensity of the forced and induced draft, a balance pressure may be obtained in the furnace chamber when varying amounts of coal are being burned. Therefore, this draft system operates not only to overcome the resistance due to the passage among the heating surfaces, but also insures complete combustion with a smaller air supply than would be the case with induced draft alone. This condition has been referred to as that of balanced draft. In this connection it may be well to call attention to the fact that forced draft cannot be depended upon to compel the flow of gases among the heating surfaces to any great extent, because when the pressure in the furnace chamber becomes greater than that of the atmosphere, the flames and fire will blow out through the doors, cracks, or other openings.

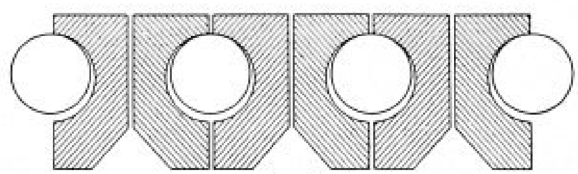


FIG. 3.

Figures are as yet not available, showing the exact effect of this particular arrangement of baffles, but results in a similar case of baffling will serve to indicate that a high efficiency is attainable. So far as the author is aware, there are no features of the above apparatus which are patented.

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - New York

Christopher St., Finsbury Square, London, E. C.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico........	$1.00	.10
Other countries in Postal Union..........	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

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 5,800 *copies.. We have no free list, accept no return copies, and issue only enough to supply the regular demand.*

An Appeal to the Foremen and Layers-out.

We quote the following from a letter which has been widely circulated among the boiler makers of this country by Mr. J. T. Goodwin, secretary of the International Railway Master Boiler Makers' Association:

"We take the liberty of addressing you on a subject which we feel is of deep import to you, as well as to your employer. If you are a member of the Master Steam Boiler Makers' Association or the International Railway Master Boiler Makers' Association, you are doubtless acquainted with the aims and objects of an association to broaden the usefulness of every foreman or assistant foreman in the profession of boiler making to-day. It is an organization which brings them together annually for the purpose of interchanging ideas for advancement and progress in their line of work, whereby experience and technical education can be gained. Should not such a movement appeal to you as a most desirable incentive to work for, and do you not think that unquestionably it would be beneficial to you and the people you represent to brighten up your mind occasionally with the experience of other men? Our association feels that your experience is educational to us, as well as ours to you, and after once attending one of these meetings you would readily see the advantage of association with us, and it would doubtless be estimated very highly by you."

We are so much in sympathy with the aims and objects of both of the above-named associations that we strongly urge each one of our readers to consider this a personal appeal, and unite his influence with the strong organization which is to be the outcome of the amalgamation of these two associations at the convention which opens in Cleveland, Ohio, on May 21.

The Education of Apprentices.

The success of the experiment which has been tried at the Sedalia shops of the Missouri-Pacific Railroad for the technical education of apprentices, an account of which is given on another page of this issue, should lead others to investigate this matter. The advantages of having a force of intelligent and well trained employees in any shop are too well known to need further comment here. The question is how to get such a force.

The boiler makers' apprentice, as a rule, has had only limited opportunities for education, since many of the boys have been obliged to leave school and go to work after having completed only the lower grades of the grammar school. How then is he to acquire a sufficient knowledge of arithmetic, algebra, geometry, mechanics, etc., to enable him to hold a responsible place in the boiler making industry? His only time for study is in the evening when, after a hard day's labor, his work is apt to be dispirited and half-hearted. He has no instructor to supervise his work and place it before him in an organized and scientific way, and he loses the enthusiasm and interest which come from carrying on any study with others.

Taking into consideration the conditions under which the apprentice must work, and his needs, some of the advantages of the system as worked out at Sedalia are very apparent. Here the school work is made a part of the every-day shop work, the management of the shops furnish a school room and permit the apprentices to take the time for recitations from their regular working time. The foremen and others in charge are requested to attend enough of the recitations to follow the progress of the students, and to help the individual students as much as possible. The question of a competent instructor has been solved by a correspondence school, and it is fair to say that the success of this particular school is in a large measure due to the personality of the instructor in charge of the work. He is a thoroughly practical man and one whose interest in the young men is so keen that he has been able to bring out the ability of the members of his classes in a remarkable way.

Since the school work is practically made compulsory in connection with the regular work, it will be seen at once that any apprentice who does not enter into the spirit of the school work is likely to fall into disfavor in the shop work, and thus there is bound to be dissatisfaction among a few on account of this arrangement. The majority of apprentices, however, can be relied upon to recognize the fact that they are getting exceptional advantages and carry on the work accordingly. It is true that the apprentice does not have the advantage of this instruction without some self-sacrifice on his part; for in order to keep up with the work it is necessary that he spend many of his evenings studying. He has, however, the incentive of working with others, and the sure reward of a good position at good wages with all reasonable chances for promotion and advancement if he should stay with the company which has given him this instruction.

TECHNICAL PUBLICATIONS.

"Modern American Lathe Practice." By Oscar E. Perrigo, M. E. Size, 9¼ by 6 inches. Pages, 424. Illustrations, 314: Norman W. Henley Publishing Company, New York. Price, $2.50.

The subject of the modern American lathe from its earliest development to its latest types is taken up in a very thorough and instructive manner in this book. The first two chapters give an interesting history of the earliest forms of lathes. Then a classification of the different parts of the modern lathe is taken up in detail. Following this are chapters on the design of each individual part of the lathe. This part of the work has been most carefully written from the author's wide experience, and forms a very valuable part of the book. There are also chapters on lathe attachments, lathe tools, lathe work, and finally each type of modern lathe is taken up in detail and its construction and operation carefully explained. One chapter is devoted entirely to the electrically-driven lathe.

This work should prove of value not only to the machinist and designer, but also to the man who must install such machinery in a manufacturing plant, since the types of lathe best fitted for different kinds of work are here fully explained.

The book is clearly written and finely illustrated and treats of the subject in a complete and comprehensive manner.

"Modern Steam Engineering." By Gardner H. Hiscox, M. E. Size, 9 by 6 inches. Pages, 477. Illustrations, 405. Norman W. Henley Publishing Company, New York. Price, $3.00.

The rapid advances which are being continually made in the field of steam engineering give the latest work covering that field, if it is thoroughly up-to-date, a certain value simply from the fact that it contains all the recent data and information which has come into use. This work takes up both the theory and practice of steam engineering, starting from the generation of steam, and following through its many applications for the generation of power, and its use in refrigerating and elevator machinery. Some attention is also given to the cost of steam power and the development of the steam turbine and its work.

There are special chapters on electrical engineering by Newton Harrison, E. E., which should prove of value to the modern engineer, since few steam plants are in use to-day in which electricity does not play an important part. It is a book especially adapted for the use of the man who has charge of a steam power plant.

COMMUNICATIONS.

Lap Joint Boilers from an Insurance Engineer's Point of View.

EDITOR THE BOILER MAKER:

The lap seam, which has given so much trouble (apparently), and incidentally enabled the boiler makers and insurance companies to make and lose a little money now and then, it would appear, has to go. The lap seam, this bugbear for some people, has done good service, nevertheless, considering that practically all the boilers built for anything over fifty pounds steam pressure during the last thirty years were built with this style of seam, and at the present time there is no doubt that at least eighty percent of all the boilers in use are of the lap seam construction.

Boiler explosions will continue to occur however. There need not be so many, of course, and we should certainly like to see less. When there is a boiler explosion, it appears to be usual to conclude that it was surely due to the faulty metal concealed in the lap seam. Here is a boiler that, after having been in service ten years and doing good work, suddenly explodes. The boiler was of the lap seam construction, built for one hundred pounds pressure with a factor of safety of five, and was run for ten years at one hundred pounds pressure. At the time of the explosion it was still good for one hundred pounds pressure, yet the boiler exploded, and the cause of the explosion was attributed to the lap seam, and we are led to wonder whether there would not have been an explosion even though the boiler in question had been built with the butt strap seam. In a great many instances, it has been proved that the seam had nothing to do with the explosion of the boiler, as under the circumstances of most cases it would not have mattered whether the boiler had been built with the lap seam or with the butt strap joint.

We should not like to give the impression that the lap joint in a boiler is considered the best practice, because it is not, and although the butt strap joint in some instances will give us only some slight advantage in efficiency over a well designed lap joint, it is, from any point of view, the proper joint, and should be universal. The assistance of the authorities in the different States will not even be necessary to bring this about, as the demand for higher pressures will, as a matter of course, necessitate the use of the butt strap joint exclusively. We read almost daily of boiler explosions. Of course, many of these explosions are on boilers of the lap seam construction, on account of the large proportion of this class of boiler in use, but from the way in which this matter has been taken up by some newspapers recently, we are given the impression that they consider that all boiler explosions are due to the lap seam, when such is not the case. The butt strap seam was not designed for the express purpose of doing away with the lap seam. The butt joint was designed in order to permit the higher pressures, which are required to-day, to be carried, and is the natural logical outcome in the evolution of mechanics.

While it is true that in a great number of the older lap seam boilers the seams are so placed as to be very inaccessible to the inspector, we think, however, that instead of condemning boilers with the lap seam altogether on account of this difficulty, builders of boilers should be enjoined from so placing the seams, and to oblige them instead to place the longitudinal seams of the boiler where they could be inspected without trouble. This is invariably the practice now in all shops where good work is done, but it would be well to have it insisted upon in all specifications.

To condemn indiscriminately all boilers which happen to have had the misfortune to have been designed with the lap seams, would be absurd, as aside from shortness of water and the lap seam, there are other causes to which boiler explosions can be attributed, and even the general adoption of the butt strap joint will not prevent them altogether, by any means, although some people seem to think so. Out of seven explosions which we have personally investigated within the last three years, the most serious was on a boiler with the butt strap seam; the other six were on boilers of the lap seam construction, but the joint or seam had nothing whatever to do with the wrecking of the boilers, as the seams were in each instance found intact. There are, of course, cases where the lap joint has given away, but the cause has usually been from overpressure or other undue stress upon the boiler, and the same thing is just as likely to occur on a boiler with the butt strap joint.

Boilers at present in use with the lap seam, if they have been properly designed and honestly inspected during construction, require no further safeguard than proper care by competent and conscientious men, together with honest inspections and the enforcement of all recommendations made by the inspector in the interest of the general safety.

G. M. DOUGLASS,

Arithmetic of Boiler Stays.

EDITOR THE BOILER MAKER:

In looking over the April issue of THE BOILER MAKER, I have read with interest the article "Arithmetic of Boiler Stays," by Mr. Chas. J. Mason, and am glad to see some of these formulæ expressed in simple terms. I would, however, call your attention to formula three, in which I believe a wrong term has been used. This formula states that the

$$\frac{\text{Area supported by one stay} \times \text{pressure per square inch}}{\text{area of one stay}} =$$

allowable tensile strength per square inch of section.

In reality, this fraction equals the fiber stress in tension per square inch of section, which is altogether different from the allowable tensile strength. The allowable tensile strength depends upon, not the above formula, but the ultimate tensile strength of the material employed and the factor of safety which it is desired to have; or, if the boiler is being designed or figured under certain rules, as the United States rules for marine boilers, the British Board of Trade rules or British Lloyds, etc., this allowable tensile strength is given to begin with and is not a factor to be computed.

Formula three referred to is, of course, correct, excepting it would seem to the writer that the term "allowable tensile strength" should not be used in connection with it.

R. E. ASHLEY.

Rolling Boiler Plate.

EDITOR THE BOILER MAKER:

In laying out shell plates for boiler work I have always used the center of the thickness of the plate as the neutral axis. This practice is all right for thin plates, and also for heavy plates, except that an allowance must be made.

Suppose we are laying out the shell plates for a boiler 15 feet in diameter, plates 1⅜ inches thick. If the butt ends of the plates are planed square and the plates then rolled up, they will not make a close butt. The inside of the butt-joint will be quite close, but on the convex or outer side the butt will be open. An allowance must be made for this.

As I said before, I use the center of the thickness of the plate for convenience in taking sizes, then when the plates are planed to size they are slightly beveled at the butt. On a 1⅜-inch plate an allowance of 1-32 inch is made on each butt end of each plate. If two plates are used for each ring or circumference there would be a difference of ⅛ inch in total length between the convex and concave sides of the plate before bending. I have found this to be good practice in my own experience, ensuring a close butt and also a good fit between outer and inner rings and also at the heads.

J. CROMBIE.

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.—Will some of the readers of THE BOILER MAKER give in detail the layout of a Y breeching?

TRAMS.

Q.—1. How many foot-pounds of energy are contained in a horizontal return tubular boiler 5 feet in diameter, 15 feet long, containing sixty-six 3-inch tubes? There are 9,500 pounds of water in the boiler, the remaining space being filled with steam at 75 pounds gage pressure.

2. How do you figure the bursting pressure of the above-mentioned boiler without the use of a constant, assuming ⅜ inch as the thickness of the shell? I notice in your April issue that in figuring the bursting pressure of the boiler which exploded on the steamship *Valdivia,* you multiplied the tensile strength of the plate by the thickness of the plate and divided by 31.5. Why do you divide by 31.5?

3. How do you find the force tending to rupture the above-mentioned boiler longitudinally?

4. How do you find without the use of a constant the thickness of shell necessary for the above-mentioned boiler?

5. How do you find the efficiency of a single-riveted joint, and also of a double-riveted joint without the use of a constant?

6. How do you find the pitch of rivets in a single-riveted joint, and the distance between rows in a double-riveted joint without the use of a constant?

EXPANDER.

A.—1. The volume inclosed by the boiler shell is equal to

$$3.1416 \times \frac{(\text{the diameter})^2}{4} \times \text{the length.}$$

$$\frac{3.1416 \times 25 \times 15}{4} = 294.5 \text{ cubic feet, the volume of the shell.}$$

The volume of sixty-six 3-inch tubes, 15 feet long, is equal

$$\text{to number of tubes} \times \text{the length} \times 3.1416 \times \frac{(\text{the diameter})^2}{4}.$$

$$\frac{3.1416 \times 66 \times 15}{4 \times 4 \times 4} = 48.6 \text{ cubic feet, volume of the tubes.}$$

$294.5 - 48.6 = 245.9$ cubic feet, space occupied by the steam and water in the boiler.

The temperature of saturated steam at 75 pounds gage pressure is found from tables of the properties of saturated steam to be 319.8 degrees F.

One cubic foot of water at 319.8 degrees F. weighs 56.58 pounds. Therefore, the 9,500 pounds of water in the boiler occupies a volume of $\frac{9,500}{56.58} = 167.9$ cubic feet, volume of the water in the boiler. The volume of the steam is equal to the total volume in the boiler, minus the volume of the water, or $245.9 - 167.9 = 78$ cubic feet, volume of steam in the boiler.

We find from tables of the properties of saturated steam that 291 thermal units are required to raise 1 pound of water from the freezing point to a temperature of 319.8 degrees F., which is the temperature corresponding to 75 pounds gage pressure. One thermal unit is equal to 778 foot-pounds, therefore, the energy in the hot water in the boiler calculated from the freezing point is $9,500 \times 291 \times 778 = 2,150,781,000$ foot-pounds.

After the water is heated to 319.8 degrees F., there will be required 888.5 thermal units to vaporize 1 pound of the water into steam at 75 pounds gage pressure. This quantity is also found from tables of the properties of saturated steam, and is known as the latent heat of vaporization. But 80.1 thermal units will be expended in changing the volume of the fluid when it passes into steam. This quantity is determined from the following formula, and is known as the external latent heat, or the heat used up in doing work against the external pressure. The formula is $59.191 + .0655 \times$ the temperature of the steam.

$59.191 + .0655 \times 319.8 = 80.1$. Since this heat is no longer contained in the steam, this quantity must be subtracted from the total heat of vaporization.

888.5 — 80.1 = 808.4 thermal units, the internal heat in 1 pound of steam at 75 pounds gage pressure. Therefore, the heat stored in a pound of steam is 291 + 808.4 thermal units.

We found that we had 78 cubic feet of steam. One cubic foot of steam at 319.8 degrees F. weighs .2073 pounds. Therefore, we have 78 × .2073 = 16.17 pounds of steam in the boiler. Therefore, the equivalent energy stored in 16.17 pounds of steam is 16.17 × (291 + 808.4) × 778 = 13,830,738 foot-pounds, energy in the steam.

Therefore, the total energy in the boiler, figured from the freezing point is 2,150,781,000 + 13,830,738 = 2,164,611,738 foot-pounds.

2. The total pressure on a strip of the shell 1 inch long is equal to the radius, times the bursting pressure. This is resisted by the strength of the 1 inch section, which is equal to the 1 × the thickness of the plate × the tensile strength. Therefore, bursting pressure

$$= \frac{\text{the tensile strength} \times \text{the thickness of the plate.}}{\text{radius of the boiler}}$$

Or, $\frac{60{,}000 \times .375}{30}$ = 750 pounds per square inch, bursting pressure.

In the case of the *Valdivia*, the diameter of the boiler was 63 inches. Therefore, the radius of the boiler was one-half of this, or 31.5, which, in that case, was used in place of 30 in the above formula. You will see that the above formula involves no constants, and is solved from the dimensions of the boiler and the strength of the material.

3. To find the force tending to rupture the boiler longitudinally, the above formula may be used, substituting for the tensile strength the unknown value of the bursting force. Therefore,

$$F = \frac{\text{the radius} \times \text{the pressure in pounds per square inch.}}{\text{thickness of the plate}}$$

$\frac{30 \times 75}{.375}$ = 6,000 pounds per square inch, force tending to rupture the boiler longitudinally.

4. The above formula may also be used to solve for the thickness of the plate. The thickness of the plate =

$$\frac{\text{radius of boiler} \times \text{pressure in pounds per square inch.}}{\text{allowable tensile strength}}$$

In this case the allowable tensile strength is not the breaking strength of the material, but that quantity divided by a factor of safety. Using 6,000 pounds as the allowable tensile strength, the thickness of the plate is found to be $\frac{30 \times 75}{6{,}000}$ = .375 inch.

5. The efficiency of either a single or double-riveted joint may be found by dividing the strength of the joint for a given length by the strength of the solid plate for the same length. In a well-designed joint, the joint will probably be weakest in the section of plate at the outer row of rivets. Therefore, the

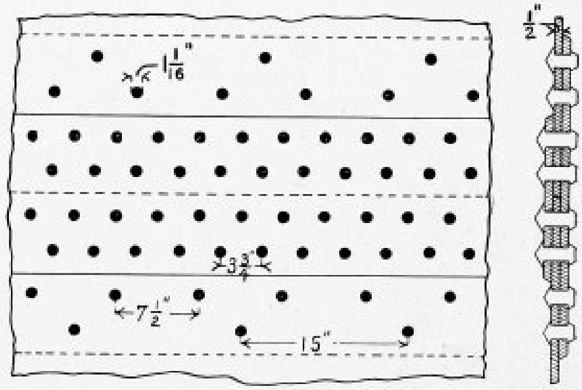
$$\text{efficiency} = \frac{(\text{pitch} - \text{diameter})}{\text{pitch}} \times 100.$$

As this may not always be the least efficiency, the shearing strength of the rivet section, and, in a double-riveted joint, the strength of the rivets to resist crushing, should also be figured.

6. If p = pitch, d = diameter, t = thickness of plate, T = tensile strength of plate, Ts = shearing strength of rivets, the resistance of the joint to tearing the plate between the rivet holes is $(p - d) \times t \times T$. The strength of the rivet section is $\frac{3.1416 \times d^2}{4} \times Ts$. These two resistances should be made nearly equal in a well-designed joint. Therefore, if the diameter of rivets has been decided, the pitch may be determined by equating these two resistances, substituting the diameter of rivets and solving for p.

The distance between rows in a double-riveted joint does not effect the efficiency of the joint, and is governed largely by practical reasons. It must be small enough to insure a steam-tight joint and large enough to give plenty of room to drive the rivets. It is usually determined from a consideration of the diagonal pitch of the rivets, which should be made not less than $.6p + .4d$.

Q.—Will some of the readers of THE BOILER MAKER show how to figure the double-butt strapped joint shown in the accompanying sketch? The plate is ½ inch in thickness, and the rivets are 1 1-16 inches in diameter when driven. The two



QUADRUPLE RIVETED BUTT JOINT.

inner rows of rivets, which are in double shear, are spaced 3¾ inches between centers, while the two outer rows, which are in single shear, are spaced 7½ and 15 inches, respectively, as shown in the sketch. E. P.

A.—In figuring the above joint, assume the tensile strength of the plate to be 60,000 pounds, the shearing strength of the rivets 38,000 pounds and the excess strength of rivets in double shear over those in single shear, 85 percent.

The first mode of failure will be the rupture of the plate through the outer tow of rivets. Consider a section 15 inches long.

15 — 1 1/16 = 13 15/16 inches.

$\frac{13\ 15/16}{15}$ = 92.9 percent, efficiency of the joint for this mode of failure.

The second mode of failure will be a rupture of the plate through the second row of rivets. The strength of the solid section of plate 15 inches long is 15 × .5 × 60,000, or 450,000 pounds.

15 — 2⅛ = 12⅞ inches.

12⅞ × ½ × 60,000 = 386,250 pounds.

386,250 + 33,691 (strength of one rivet in single shear) = 419,941 pounds.

$\frac{419{,}941 \times 100}{450{,}000}$ = 93.3 percent, efficiency.

The third mode of failure will be a rupture of the plate through the first row of rivets in double shear.

15 — 4¼ = 10¾ inches.

10¾ × ½ × 60,000 = 322,500 pounds.

322,500 + 101,073 (strength of three rivets in single shear) = 423,573 pounds.

$$\frac{423{,}573 \times 100}{450{,}000} = 94.1 \text{ percent, efficiency.}$$

In the fourth mode of failure the plate remains intact, but all the rivets are sheared.

33,691 × 3 + 62,328 × 8 = 599,697 pounds.

$$\frac{599{,}697 \times 100}{450{,}000} = 133.2 \text{ percent, efficiency.}$$

It will be noticed that I have not figured the joint as liable to rupture on the inside row of rivets. This is unnecessary since the strength of the joint at this point would be much greater than that found by the third mode of failure.

Also, since the thickness of butt straps is not given it is not possible to figure the strength of these, but if the straps are not less than ¾ the thickness of the sheet, there is no danger whatever of their failing. A. B. C.

Assuming 60,000 pounds tensile strength of plate; 40,000 pounds shearing strength of rivets, and 75 percent excess strength of rivets in double shear over those in single shear, the joint would be figured as follows:

Strength of one rivet in single shear, $1\ 1/16^2 \times .7854 \times 40{,}000 = 35{,}465$ pounds.

Strength of one rivet in double shear, $1\ 1/16^2 \times .7854 \times 40{,}000 \times 1.75 = 62{,}063.7$ pounds.

Strength of 15" section of plate equals 15 × ½ × 60,000 = 450,000 pounds. 62,063.7 × 8 + 35,465 × 3 = 602,804 pounds, strength of rivets in 15-inch section of plate.

$$\frac{602{,}804}{450{,}000} = 133.9 \text{ percent, efficiency of rivets in the joint.}$$

15 − 1 1/16 = 13 15/16 inches, distance between the holes in the outer row of rivets.

13 15/16 × ½ × 60,000 = 418,125 pounds.

$$\frac{418{,}125 \times 100}{450{,}000} = 92.9 \text{ percent, efficiency of the joint at the}$$

outer row of rivets.

15 − 4¼ = 10¾ inches.

12⅞ × ½ × 60,000 = 386,250 pounds, strength of the plate at the second row of rivets.

386,250 + 35,465 (strength of one rivet in single shear) = 421,715 pounds.

$$\frac{421{,}715 \times 100}{450{,}000} = 93.7 \text{ percent, efficiency of the joint at the}$$

second row of rivets.

15 − 4½ = 10¾ inches.

10¾ × ½ × 60,000 = 322,500 pounds, strength of the plate at the first row of rivets in double shear.

322,500 + 106,395 (strength of three rivets in single shear) = 428,895 pounds.

$$\frac{428{,}895 \times 100}{450{,}000} = 95.3 \text{ percent, efficiency of the joint at the}$$

third row of rivets.

322,500 + 106,395 (strength of three rivets in single shear) + 248,252 (strength of four rivets in double shear) = 677,147 pounds.

$$\frac{677{,}147 \times 100}{450{,}000} = 150.4 \text{ percent, efficiency of the joint at the}$$

inner row of rivets.

The strength of the plate at the outer row of rivets being the weakest part of the joint, the efficiency of the joint is 92.9 percent.

I also submit the following joint, shown in Fig. 1, which has an efficiency of more than 100 percent. The plates should be upset on the ends to equal the amount of material removed in drilling the holes. Assuming a 3½-inch pitch, ½ inch thickness of plate, 60,000 pounds tensile strength and 40,000 pounds shearing strength of rivets, the joint would be figured as follows:

3½ × ½ × 60,000 = 105,000 pounds, the strength of a section of solid plate 3½ inches long.

105,000 × ½ × 4/7 = 30,000.

$$\sqrt{\frac{30{,}000}{40{,}000} \times .7854} = \frac{173}{177} = D,$$ the required diameter of rivets double staggered and in double shear to equal 100 percent, strength of the plate. As 1 inch is the nearest standard

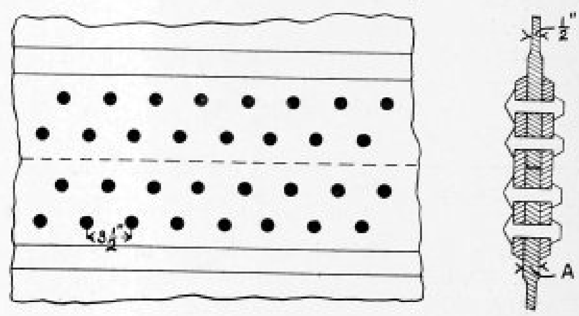


FIG. 1.

diameter above this value, use 1 inch for the diameter of the rivet holes.

$1^2 \times 40{,}000 \times .7854 \times 1.75$ (excess for double shear) × 2 (number of rivets) = 109,956 pounds.

$$\frac{109{,}956 \times 100}{105{,}000} = 104.7 \text{ percent, efficiency of the rivets in the}$$

joint.

3½ − 1 = 2½ inches.

$$\frac{2/5 \times 109{,}956}{60{,}000} = .734 \text{ inch, thickness of plate at } A, \text{ neces-}$$

sary to equal the strength of the rivets.

5/2 × .734 × 60,000 = 110,100 pounds.

$$\frac{110{,}100 \times 100}{105{,}000} = 104.8 \text{ percent, strength of the plate in the}$$

joint.

Since the rivets are the weakest part of the joint, the efficiency is equal to 104.7 percent. It will be noted that by increasing the rivets in the joint and the thickness of plate at *A*, the strength of the joint is limited only by the will of the designer.

JOHN A. DOWD, Foreman,
Fall River Boiler Works, Fall River, Mass.

The joint may fall (1) by the plate fracturing through the outside row of rivets, as indicated in Fig 2; (2) by a fracture of the plate through the next row of rivets combined with a shear of the outer row, Fig. 3; (3) by the failure of the plate through the next to the inner row of rivets and the shear of the two outer rows, as indicated in Fig. 4; and (4) by shearing of the rivets, as is Fig. 5.

Assume that the plates and rivets are of steel; the plates having a tensile strength of 60,000 pounds, and the rivets a shearing strength of 42,000 pounds in single shear, and 1.85 times that in double shear. Since the diameters of one rivet is 1 1/16 inches, the shearing strength of one rivet in single shear will be 37,275 pounds, and the shearing strength of one rivet in double shear will be 68,959 pounds.

If the joint breaks across the outer row of rivets, or according to the first mode of failure, as shown in Fig. 2, the length of the fracture in each unit of the joint is equal to 15 — 1 1/16 = 13.8375 inches. The efficiency of the joint is found by dividing this length by the total of the section, 15 inches.

$$\frac{100 \times 13.9375}{15} = 92.9 \text{ percent.}$$

If the failure occurs according to the second mode of failure, we have a fracture whose length is 15 inches minus the diameter of two rivet holes, and also the shear of two half-rivets. The length of plate fractured is, therefore, 15 — 2⅛ inches = 12.875 inches. The strength of this section is 12.875 × .5 × 60,000 = 386,220 pounds. Adding to this 37,275 pounds, which is the strength of the rivet which must be sheared in the outer row, we find the total force required to fracture a section of

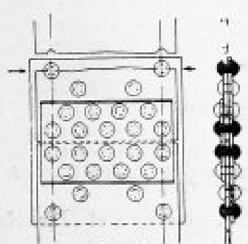


Fig. 2

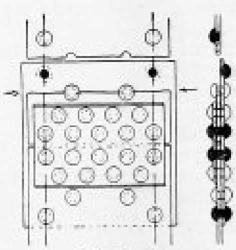


Fig. 3

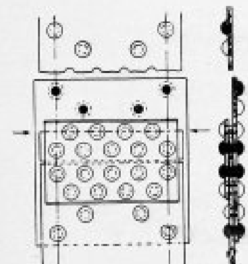


Fig. 4

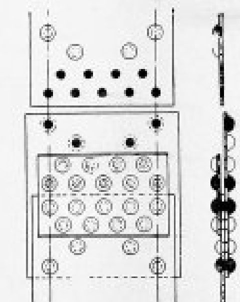


Fig. 5

the joint by this method is 423,495 pounds. The strength of a solid section of plate 15 inches long is 15 × .5 × 60,000 = 450,000 pounds. The efficiency of joint for this mode of failure is, therefore,

$$100 \times \frac{423,495}{450,000} \text{ or } 94.2 \text{ percent.}$$

In the third mode of failure the plate is broken, as shown in Fig. 4, and a section of rivets equal to three whole rivets in single shear is sheared. The length of the fractured plate is, therefore, 15 — 4 × 1 1/16, or 10.75 inches, the strength of which is 10.75 × .5 × 60,000 = 322,500 pounds. The shearing strength of the three rivets in single shear is 3 × 37,275 = 111,825 pounds. Therefore the force required to fracture the joint in this way is 322,500 + 111,825 = 434,325 pounds, and the efficiency is

$$100 \times \frac{434,325}{450,000} = 96.5 \text{ percent.}$$

The total force required to fracture the section of joint, according to the fourth mode of failure, will be the combined resistance of three rivets in single shear and eight in double shear, or

3 × 37,275 = 111,825 pounds.
8 × 68,959 = 551,672 pounds.
68,959 + 551,672 = 663,497 pounds.

$$\text{The efficiency is, therefore, } 100 \times \frac{663,497}{450,000} = 147.4 \text{ percent.}$$

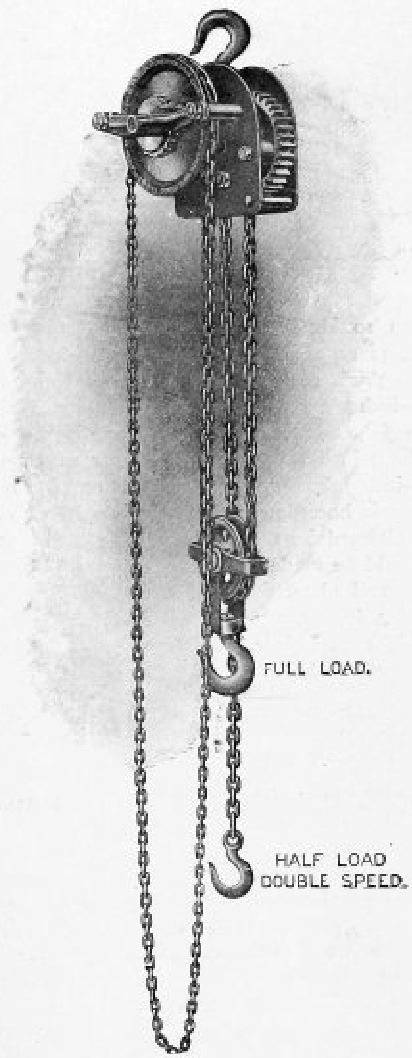
The foregoing calculations show that the efficiency of the joint is least at the outer row of rivets. The joint will fail, therefore, according to the first mode of failure for which an efficiency of 92.9 percent was found.

CHAS. J. HIMES.

ENGINEERING SPECIALTIES.

The Axallwazo Chain Block.

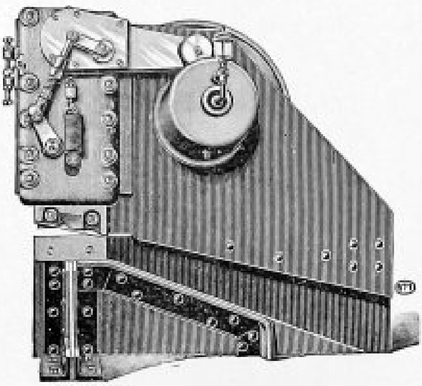
Rowland Priest, of Lomey Town, Cradley Heath, England, has placed upon the market a spur gear differential hoist fitted for two speeds, and so arranged that a double chain is used for lifting the full load, while a single chain lifts loads up



to half the capacity of the block at double the full-load speed. This arrangement renders the block especially handy. The efficiency is said to be very high, particularly when compared with worm-gear blocks, while the lowering of loads is said to be under absolutely perfect control. The block is built in seven different sizes, the maximum capacities being, respectively, ½, 1, 1½, 2, 3, 4 and 5 tons. In each case the block is tested by dead weight to 50 percent more than rated load. The approximate weight of the block complete, with chains for a 10-foot lift, is 70 pounds for the smallest, and 294 pounds for the largest capacity.

Johns Patent Plate Shear.

When settling the question of economy in boiler shops, or buying new machines, an important question is very often overlooked. This important point is the question of the horsepower that a tool needs for running up to its maximum capacity. The cost of 1 H. P. per year is generally figured at $50. It, therefore, makes a difference at the end of the year whether, for instance, 5 H. P. more have been used, as these 5 H. P. would cost approximately $250, which is equivalent to 6 percent interest on $4,000 invested capital, or 10 percent on a depreciation of a tool for which $2500 has been paid. It must, therefore, be quite interesting for our readers to learn that while rotary splitting shears for ¾-inch plates require



7½, or even 10 H. P., it is claimed that the Johns patent plate shear, manufactured by Henry Pels & Co., 68 Broad street, New York, requires only 4 H. P. It is also claimed that the ½-inch rotary splitting shear requires 4 H. P., while the ½-inch Johns patent plate shear requires only 2 H. P., and that the 1-inch rotary splitting shear requires 15 H. P., while the 1-inch Johns patent plate shear requires only 5 H. P. The economy in horsepower is, however, only one of the many advantages claimed for the Johns patent plate shears. Special mention should be made of the frame, which consists of one solid-rolled steel plate, which, for a ¾-inch machine, has a thickness of 3 inches, while a 1-inch plate shear is built of a solid 3½-inch steel plate. This, of course, makes these machines absolutely unbreakable.

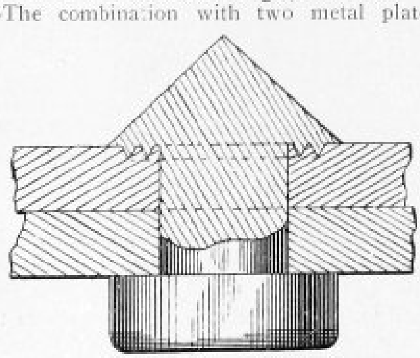
SELECTED BOILER PATENTS.

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.

845,228. RIVETING. Harry C. French, of York, Pa., assignor of one-half to Charles F. Borgel, of York.

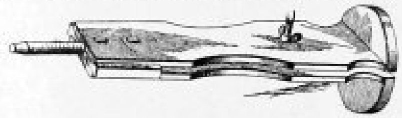
Claim.—The combination with two metal plates having



aligned rivet holes, of a rivet passing through said holes to permanently unite said plates, said rivet having an integral head at its outer end, lying against the outer face of one of said plates, said face having a groove or plurality of grooves around the rivet hole to receive a portion of the metal of the rivet head. Four claims.

843,976. BOILER-FLUE CLEANER. James P. Thompson, Hagan, Ga.

Claim.—The herein-described boiler-flue cleaner consisting essentially of a flat stock of greater width than thickness having longitudinal flanges extending laterally in opposite directions from its side edges, resilient blades arranged against opposite sides of the intermediate portion of the stock and oc-



cupying the spaces between the flanges of the stock and having blades at their forward ends extending outward at right angles to their main portions; one of said blades also having a threaded aperture at an intermediate point of its length, means extending through one of the blades, the intermediate portion of the stock and the other blade in the order named and connecting the blades to the stock, a screw bearing in the threaded aperture of one blade and arranged with its inner end against the inner side of the other blade and having its outer end flattened to form a finger-piece, and a wing-nut mounted on the said screw between the outer side of the blade in which the screw bears and the outer flat end of the screw. One claim.

824,633. WATER-TUBE BOILER. Harry Del Mar, New York, N. Y., assignor to Boilers & Engineering Company, Jersey City, a corporation of New Jersey.

Claim.—A cross-tube sectional boiler having upper and lower headers on each side of the boiler, cross-tubes connect-

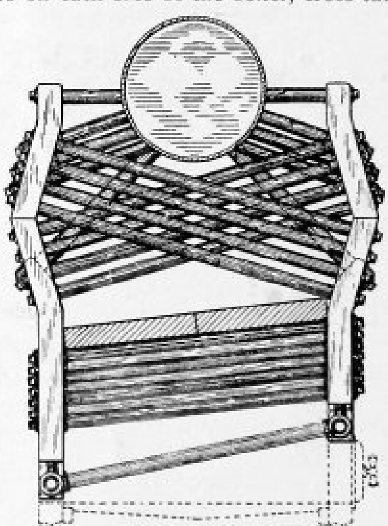
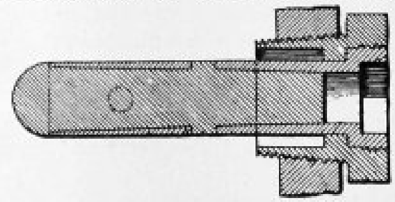


Fig. 3

ing the upper headers to the upper parts of the lower headers opposite, and the lower part of the lower headers having bent or serpentine portions with tubes arranged in a staggered position therein, said tubes connecting the lower part of the lower headers on one side of the boiler with the lower part of the lower headers on the opposite side of the boiler. Eight claims.

848,206. SAFETY PLUG. Bliss W. Robinson, of Boston, Mass.

Claim.—A safety plug for boilers provided with a cham-



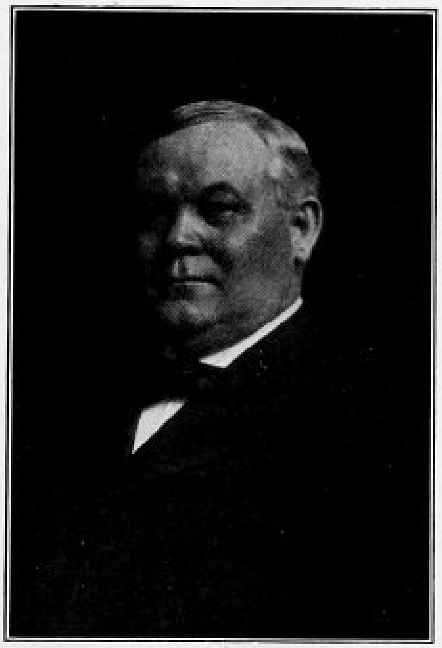
ber containing fusible material and another chamber constituting a water-space surrounding the first-named chamber. Ten claims.

THE BOILER MAKER

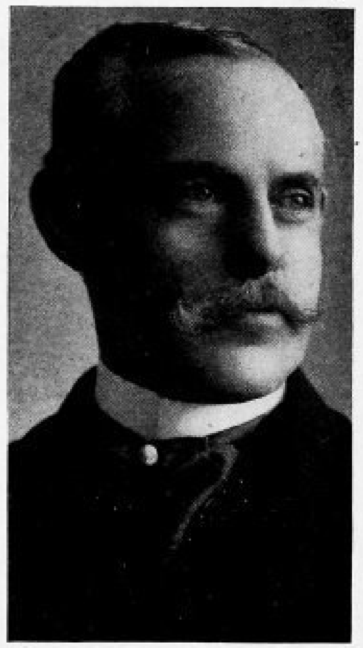
VOL. VII JUNE, 1907 No. 6

THE JOINT CONVENTION.

The joint convention of the International Railway Master Boiler Makers' Association and the Master Steam Boiler Makers' Association was held at the Hollenden Hotel, Cleveland, Ohio, May 21, 22 and 23. The convention was opened at 10 A. M. May 21, with President Hempel, of the Railway Master Boiler Makers' Association, in the chair. After an invocation by Reverend Buehler Pratt, of the Euclid Avenue Methodist Church, Mr. Harris M. Cooley, member of the Board of Public Service, welcomed the associations to the city in behalf of Mayor Johnson.



GEORGE WAGSTAFF, PRESIDENT.



HARRY D. VOUGHT, SECRETARY.

The first address was delivered by Mr. J. F. Deems, S.M.P. and R.S., of the New York Central lines. We regret that this speech cannot be given in full, as Mr. Deems requested that no notes be taken. He spoke along the lines of shop practice, and admonished his hearers especially to train others to take their places when they retired from the work. He congratulated the convention on the proposed consolidation.

President Smythe, of the Master Steam Boiler Makers' Association, responded briefly to Mr. Deems, and then introduced Mr. Harry D. Vought, secretary of the New York Railway Club.

ABSTRACT FROM THE ADDRESS OF MR. HARRY D. VOUGHT.

"To tell you about organization would be to say briefly: It means, get together, stick together, work together, stay together, and to that end work for one another, live for one another, maintain brotherly love, be tolerant, and, like the Scottish bard, lift up your voice in a prayer that some power endow you with the gift to see yourself as others see you.

"We learn from the ponderous volume to which we resort for enlightenment as to a definition or synonym, and which a young woman was once heard to designate as her 'Uncle Dick,' that among other things organization is the 'act of forming or arranging the parts of a complex body in a suitable manner for use and service; the distributing into suitable divisions, or disposition of parts which are to act together as a compact body; to construct so that one part may cooperate with another and take systematized form; that which must have a sound foundation upon which to rear the superstructure.'

"Here we appear to have not only the essence, but the concrete substance of the entire matter engaging our attention; but analysis shows that we have simply the essentials for a proper beginning; the fundamental principles incident to a formative period, the means wherewith to start right. Much more remains with respect to progressing along correct lines that perpetuity may be assured, that there may be cohesion and harmony of operation in order that there may be neither disintegration nor deterioration, that specific purpose may be achieved, that worthy object may be attained, and that at all times success may crown every proper undertaking. That all this may prevail, there must be prudent management, wise use of available forces and correct application of the highest principles. These considerations must be rigidly observed or there can be no long life—the goal originally in view can never be reached.

"Organization is as old as the hills. Creation of the world in which we live furnished the greatest example to man of the genesis of things, the bringing of order out of chaos and of correct procedure and operation. In organization we have a combination of forces that makes for great good or great evil. In their use and application we are mutually helpful or injurious, elevating or destructive, illuminative or disheartening, harmoniously progressive or chaotic and dreaded, if not despised, as a cause of retrogression.

"Candor compels the admission that we profit not alone by the lessons of personal experience, but also that of others,

J. H. SMYTHE, RETIRING PRESIDENT OF THE M. S. B. A.

provided these lessons are rightly applied. This is as true of associations as of individuals. Furthermore, there must be maintenance of activities which promote healthy growth and give stimulus, with a never ending desire for more advantages and benefits to be accorded all concerned. Always set your standards high and never be contented unless they are reached. This will give strength and influence, a constant widening and extension of the sphere of usefulness occupied.

"One of the brightest and best examples of successful organization in its policy, management and work is the New York Railroad Club. It is mentioned here because it is recognized and entitled to the proud distinction of being practically the progenitor of many other organizations of railroad men. Time will not admit of detail concerning its methods and the secret of its splendid success, but with the history of the club they are commended with pride to your contemplation and study, as well as worthy of the closest emulation by any other organization ambitious for equally high rank and unbounded usefulness.

"Recognized to-day as an essential element and made a feature of the work of many active organizations, are social divertisements. Combined with the less absorbing demands of serious business that invariably interest only a certain proportion of members, these are always salutary. They can never, with safety, however, be allowed to lead to a sacrifice of dignity or the higher intellectual objects and practical enlightenment of mankind which should be the chief aim of organization, in the intelligent exchange of opinions and in the recital of experiences demanding the best skill and knowledge.

"Associations having a widely scattered membership and meeting only once a year, do not afford equal opportunity for personal interchange of thought and opinion. There cannot be the same degree of activity and multiple benefits accruing to those connected with such as have frequent sessions. But, what is done and the results attained, can have a decidedly corresponding value. At the same time, there remains and is strongly emphasized, under the circumstances, the interdependence of the members, because it is much greater. To maintain interest and to keep the organization healthy, prosperous and successful is not so easy and so much more has to be done by officers and members. A measure of responsibility is involved for every individual that cannot be safely slighted. It demands persistent energy, unflagging diligence, constant vigilance, immediate grasp of opportunity and the liveliest appreciation of duty. If advantages certain to present themselves in your daily avocations are grasped without hesitation, every member going to the annual convention will not only be prepared to intelligently participate in its deliberations, but will profit by what he hears and learns. He will be helpful, and will be an important factor in exemplifying what the brotherhood of man means and is. So will each do his part in preserving and magnifying the unit, and prove beyond cavil or successful contradiction that, to be associated together, in spite of the limitations stated, is of real and lasting practical worth.

"To give practical value to membership, an organization must be prepared and able to show at all times that something substantial is gained from identification with its work; to prove that hours and labor given to it is not time wasted; that the interest with which men invited to unite with it are connected in order to profit by what is done. This latter consideration is sure to command individual and corporate approval and gives assurance of the best and most lasting results.

"Be careful and conscientious in your choice of officers. Failure to do so has wrecked more than one organization. See that they are men whose personal ambition does not exceed their zeal for the organization, who have the ability, the administrative capacity and the skill to initiate, to direct, and to rule with that firmness which, while maintaining harmony among the brethren, commands respect and ready recognition of authority. Gratification of individual ambition to the exclusion of what is really best for an organization is the canker that assaults and insidiously destroys its life. Personal selfishness should never be allowed to work the sacrifices that are destructive and engender unseemly strife. Once inducted into office the officers should and must have your loyal and undivided support, for it is an inspiration to unremitting effort. Those responsible for putting them in office must do their part or an important element in the attainment of uninterrupted success will be wanting. This is a duty that must be performed without hesitancy or equivocation. The obligation is imperative, and from it there is no escape if faithful to yourself, your associates and, above all, to your organization.

"But, this is not all. Great importance attaches to individual responsibility and diligent personal effort. It is the mainspring, the very life almost of an organization. It is upbuilding and uplifting. It keeps things moving. Nothing less will suffice in the increasing of membership. Enlargement of an organization is almost entirely dependent upon the intensity with which it is exercised. Vigilance is promoted. Nothing is lost sight of that will be conducive to general advancement, to the greatest good of the greatest number.

"While committee reports and conclusions based upon careful and thorough investigation are ever of immeasurable value, the introduction of individual papers is always to be encouraged. The exceptional value and profit of this idea has been sufficiently demonstrated to prove that the tendency is to elevate the standard of work and enhance the character and reputation of an organization before the world. This is a fact that has received recognition from every organization introducing individual papers as a feature of its curriculum. It has contributed to pronounced progress. It is a practice worthy of general adoption in connection with technical features that come up in daily experience. Each time a special topic is thus presented by an individual who has made his subject a matter of special study and experiment, and whose deductions are beyond captious or superficial criticism, attention is concentrated upon an organization in a manner highly beneficial and the demand for its literature increases. Men of recognized authority, either as experts or teachers, engaged in the solution of big problems, can usually be induced, when properly approached, to give you the benefit of their thought and experience.

"It is fortunate, indeed, that on such a happy occasion, we spected organization desired? Then be always zealous, united in action and effort, considerate of individual rights, and tolerant of opposing opinion and conviction. It has been truly said: 'In unity there is strength, in strength there is power, and in power is concentrated the force with which to attain a given purpose.'"

ADDRESS OF PRESIDENT SMYTHE.

"It gives me great pleasure to meet you on this, the sixth annual convention, on this great occasion when two organizations meet as one grand association. There has been much enthusiasm in regard to the consolidation of these two associations, and, in my opinion, it should be so, for the result of this action will be of lasting benefit to all concerned.

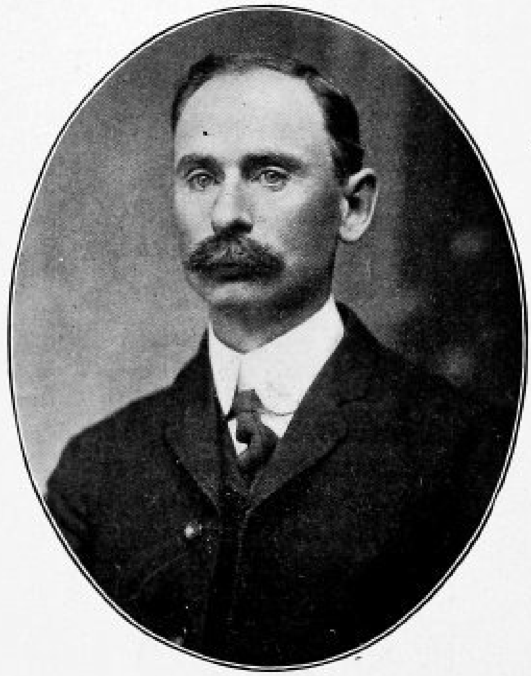
"It is fortunate, indeed, that on such a happy occasion, we have the pleasure of meeting in this beautiful city of Cleveland, a city noted for its fine buildings, grand streets and beautiful parks, a place of such great commercial importance, the leader of the lake ports in the production of steel vessels, the home of boiler makers, and the resting place of the remains of our dearly beloved President Garfield, one who was fearless in his convictions and who believed in doing the right as he saw it.

"I feel deeply gratified at the hospitality extended to us by the generous people of this city. We have been made to feel that we are welcome here, and I know I do but voice the thought of each guest present when I say that we are glad indeed to be with you in this city, and glad to accept the hospitality so kindly extended to us.

"I deeply feel the pleasure and honor of meeting you as the President of the Master Steam Boiler Makers' Association, a body of men so widely representative, a body that represents all classes of sheet iron workers. We are a company of men who believe that we do not know it all, therefore we meet to learn from one another. We believe in expansion. We know there are many problems to solve and that it is our work to solve them. We realize that the best way to accomplish these ends is for us to meet and exchange ideas, and that is our object at this time.

"These two associations remind the speaker of two lovers who have courted for a while, quarreled and said mean things to each other, and later have found out that they cannot be happy apart from each other, and have then made up and become engaged. We have had a like experience and have been engaged since last May (and the promise made more binding in September), and now we have met for the great event of becoming united. (Taking hold of the hand of President Hempel.) We, the Master Steam Boiler Makers' Association, promise to help, support and protect this grand association, and may the God of peace add His blessing to it.

"We believe there never was a time before when the public was as much interested in the boiler makers' business as at present, and it is not to be wondered at when we realize that the boiler is such a necessity in our present way of living. We find the boiler in the home, the small shop, the mill, the mine, the factory, the public building, the church, the school, in every line of public travel, and, in fact, wherever our present mode of life finds a use for steam there we find the boiler. And now one inventor sets forth his belief that the airship will never be a success until steam makes it possible. Millions of lives are spent in close proximity to countless boilers. The making of these boilers is, therefore, a very important business. Where will you find a business that requires more skill than ours?



C. L. HEMPEL, RETIRING PRESIDENT OF THE I. R. M. B. A.

The tailor cuts and fits, the carpenter shapes and joins, the smith forges and allows enough to machine off, the machinist files and fits, but the boiler maker takes the sheet of steel, lays it out, bends it and puts it together in the form of a perfect article. The least mistake would cause a great loss, not only of money but probably of lives. Not one or a few only might be put to inconvenience and suffering, but hosts. Therefore, it is necessary that we should know our business thoroughly. We *must* keep up with the times. And that is why we meet. We have been misunderstood by many, thinking that we are simply a labor organization, whose business is the physical advancement of its members. That is not our purpose. We meet not only to learn the best methods of building boilers but also to learn the best methods of handling the men who have this important work to do. Allow me to hope that we shall be successful in accomplishing these important objects.

"I beg the privilege of making a few suggestions. First, that we choose a new name for our association, and that it be short. Second, that the officers consist of president, vice-president, second vice-president, secretary, treasurer and three members of the executive board. Third, that the secretary be chosen from outside of the association, if necessary, that we may get a man who makes a business of such work. Fourth, it has been noticed in the News Bureau, in Washington, on March 9, that Secretary Strauss, of the Department of Commerce and Labor, is disappointed with the present method of steamboat inspection, and that marked reform is to be inaugurated. I would suggest, therefore, that this association appoint a committee at this time to use its influence with the proper authorities, and also that each member see his representative at Washington, to see that the inspectors of boilers are chosen from the trade instead of choosing those without practical experience."

ADDRESS OF PRESIDENT HEMPEL.

"We have gathered here to-day to shape the destiny of our profession. We have gathered here most assuredly for a great purpose; that of carrying out the fundamental principle of our association, which is education. I rejoice in that we have such splendid prospects to bring reward to those who have labored so faithfully to bring about the consolidation of these associations.

"In this advanced age of high pressure and rapid steam generation we are called upon to meet new conditions. As the railways and steamship lines become greater in the world of commerce the mechanical branch of the service becomes more intricate and scientific. Hence, the necessity of our coming together to exchange ideas and to impart the knowledge which we possess to each other that we may become more proficient in our profession and be able to meet the demands made upon us.

E. S. FITZSIMMONS, FIRST VICE-PRESIDENT.

"In this terrific war for commercial supremacy the eyes of the world are trained upon our profession. Victory can only be achieved through the mechanical and industrial branches. The only law of this twentieth century industrialism is, 'The survival of the fittest.' Boiler making to-day is one of the most important of the mechanical branches, and those who fail to avail themselves of the opportunity this association affords will soon be back numbers and must give way to the 'fittest.' We are placed in charge of departments expending from $100,000 to $500,000 per annum in labor and material, and we are expected to deliver the maximum output for a minimum outlay. We can only hope to attain the desired results by properly qualifying ourselves.

"The modern, up-to-date boiler foreman fills a position that bears with it an honor, one that is full of responsibilities. The destiny of many lives ofttimes depends upon his intelligence, mechanical ability and knowledge of his profession. Without giving the matter some serious thought one can hardly realize the responsibility that falls to the lot of boiler foremen. Few people know of the danger they are encountering when traveling upon the public highways or entering the great ships and railway terminals. Yet they look with amazement when they see the great giant of the rails and the king of the seas with their wheels in motion. They only see the exterior and never stop to think of the interior, where this great power is generated, until the press tells them of the destruction wrought and lives lost by a boiler explosion.

"Our association hopes through the medium of these annual meetings to increase the efficiency of the boiler and to render the service of our membership of greater value to our employers. We must, therefore, keep pace with the times and bring into practice better facilities and workmanship in order to take care of the boiler and guard the safety of the people.

"Above all, the boiler foreman should be a man who knows, sympathizes with, and appreciates the world of business and the world of work. The valuable man in any business is the man who can and will co-operate with other men. Men succeed only as they utilize the service and ideas of other men. Therefore, may your interest in the general moral advancement of mankind grow deeper and truer, so that your value as citizens may be increased. May the gratitude for your own happier fortunes make you more considerate of those whose progress has been impeded by less favorable circumstances, and from the elevation of your success may you remember to reach the hand of assistance to the climber below.

"A man, be he king or laborer, loves merited praise. You will pardon me if I say a few words in praise of a profession and of a people that I love. In looking over this magnificent gathering of mechanical men, this thought has forced itself upon me: Who are these men and what positions do they occupy in this busy world? Yes, my friends, were I to answer that question, I would say, 'first place.' First place, because without men of your calling progress and civilization would be at a standstill; first place, because you have been one of the greatest factors of the mechanical and industrial development of the world; first place, because you have made it possible to send the giant of the rails at lightning speed all over this broad land; first place, because you have made it possible to navigate the high seas, making international commerce possible with all the nations of the earth; first place, because you have been among the first to bare your breasts to the enemy's bullets in defense of our flag—the greatest flag of all nations."

At the conclusion of President Hempel's address the convention adjourned until Wednesday morning, to give the members an opportunity to visit the L. S. & M. S. Collingwood shops.

WEDNESDAY MORNING SESSION.

President Hempel called the meeting to order and announced that the executive committees of the two organizations, viz., Messrs. George Wagstaff, John McKeown, William W. Wilson, Chas. P. Patrick, P. J. Conrath, E. S. Fitzsimmons, T. W. Lowe, W. H. Shaw, A. E. Brown and G. W. Bennett, would retire in order to work on the constitution and by-laws, after which he turned the gavel over to President Smythe.

Arch Tubes and Brick Arches.

The first topic to be discussed was arch tubes and brick arches. The papers* which had been prepared by the members of the committee which had this topic under consideration were read by the secretary. In the paper written by Mr. G. W. Bennett, chairman of the committee, a description was given of a series of tests made on a wide fire-box boiler equipped with four 3-inch water bars; 458 tubes, 2 inches by

* These papers will be published in full in a subsequent issue.

15 feet 6 inches; fire-box, 105 inches by 74¼ inches; steam pressure, 200 pounds per square inch. The results of these tests showed that with the brick arch and arch tubes the equivalent evaporation per pound of dry coal was increased 14.9 percent over that obtained when the engine was equipped with neither the arch nor the arch tubes, and an increase of 9.3 percent over the arrangement with water bars alone. Therefore, one-third of this increase was credited to the water bars and two-thirds to the arch. The actual evaporation per pound of coal showed a gain of 13.1 percent over that obtained without the arch and tubes, and a gain of 8.4 percent over that with the tubes alone. The equivalent evaporation per pound of coal showed a gain of 12.9 percent over the arrangement with neither arch nor tubes, and a gain of 8.8 percent over that when the tubes alone were used. The coal fired per square foot of grate surface per hour was 14.7 percent less with the arch tubes and arch, and 8 percent less with the arch alone.

The experience of Mr. Thomas Lewis, of the Union Pacific, as described in the paper presented by him on this subject, showed that the principal claims for arch tubes, namely, that they assist in circulation and increase the heating surface, and therefore the steaming capacity have not made good. The only advantage found for the arch tubes was that they supported the arch bricks, but a stud was substituted which served the purpose equally well. He expressed the opinion that where certain kinds of soft coal were used, arches were necessary, but otherwise their value was very much in doubt as they were detrimental to the life of the fire-box.

In a paper presented by Mr. A. N. Lucas, a saving of fuel better than 10 percent was claimed by using arches and tubes in a narrow fire-box boiler, making a total gain of about $400,000 per year. He said that at present they were testing the hollow-brick arch and getting even better results, and that they are getting good service out of the flues and fire-boxes. Statements from the Santa Fe and Pere Marquette showed a saving of fuel of 5 percent for the solid arch and 20 percent for the hollow arch. The principal disadvantage of the arch tube as found by his experience is that it is liable to open in the seam on account of mud, and the principal disadvantage of the arches is that it is impossible to clean and calk the leaky flues, and that the engine must be out of service longer when there is fire-box or flue work to do.

The general foreman boiler maker of the New York Central lines presented a paper describing their experience with the Wade-Nicholson hollow arch. This arch has given good satisfaction since it is durable, protects the flues by having hot air pass through when the engine is not working steam; is lighter than the ordinary arch, and is easily repaired and removed.

DISCUSSION.

President Hempel stated that he had investigated the brick arch and arch tube proposition very thoroughly some time ago and had decided that there was not sufficient value in the arch tubes to pay for their maintenance, since the arch could be arranged by crowning, even in wide fire-boxes, and since the tubes added little to the steaming qualities of the boiler and were liable to rupture. He cited an instance in stationary boiler practice to show that free air admitted to the fire at a temperature of over 900 degrees is beneficial so far as combustion is concerned. He concluded by saying:

"The brick arch is necessary in locomotive service; it is economical on fuel, and I believe the time is coming when the Wade-Nicholson arch will be developed to a greater extent and will prove beneficial, as it will obviate the smoke nuisance. The brick arch is beneficial, but to my mind there is no necessity of having an arch tube. Many failures are caused by the tube blowing out."

Mr. Hennessey—On the New York Central we have always had both solid and hollow fire brick, and one of our arches is, I think, a benefit to the circulation. If the arch bars are properly applied there is no danger of their pulling out.

Mr. D. A. Lucas said that from his experience in a bad water district the arch tubes did not pull out, but burst. Tests which he made with and without brick arches in wide, shallow firebox engines showed that the arch was detrimental to the steaming qualities of the engine. His experience was corroborated by Mr. Laughridge.

Mr. A. N. Lucas spoke in favor of arches and arch tubes, saying that he had had very little trouble with arch tubes giving out, except where a few had bulged on account of mud, and that brick arches, especially the Wade-Nicholson hollow arch, had shown a saving in fuel and an abatement of smoke.

Mr. Burdette, who has had considerable experience with both the solid and Wade-Nicholson arches and is now experimenting with another form of arch, said that the Wade-Nicholson arch was found to be a heavy expense from the fact that

E. J. HENNESSEY, SECOND VICE-PRESIDENT.

as soon as a small amount of water fell on the arch it crumbled and could not be easily replaced. He admitted that the brick arch helps to consume the gases and abate the smoke, but showed that it was detrimental to the flue sheet and flues.

Mr. Troy—On the Pere Marquette, in the Saginaw district, they tried to put brick arches in without the water tubes, but found they could not get crown enough without bringing the arches up above the bottom flue. We never had any water tube pull out. Six engines were equipped with the Wade-Nicholson arches a year ago and they have not had any trouble with these tubes yet.

Mr. Laughridge stated that on a Pere Marquette engine he had trouble with the tubes drawing knots on them every 6 inches from the back end up about half the length of the tube.

A committee consisting of Messrs. Hennessey and Rogers was then appointed by President Smythe to select the papers which should be discussed at the next session, and the morning session was adjourned.

WEDNESDAY AFTERNOON SESSION.

President Hempel called the meeting to order and as the committee was not ready to report, Secretary Clark read Mr. Lowe's paper on the hydrostatic tests of boilers.

* This paper will be published in full in a subsequent issue.

Mr. Lowe was strongly in favor of testing with hot water as the boiler material becomes stronger up to about 600 degrees temperature, and the hot water test is not so liable to develop an injury to the boiler. He recommended that new boilers be subjected to a proof test of one-third the bursting pressure, receiving each successive year an excess pressure test of 25 percent above its authorized working pressure, the latter being considered for a reduction at intervals of time not exceeding five years, according to the service, condition etc., of the boiler. He cited instances to show that numerous defects had been discovered when testing boilers to excess pressures with hot water, among them being leaky seams, fractured throat sheet, defective staying, etc.

President Smythe called for opinions on the proper length of a stay-bolt to form the head.

This question brought out considerable discussion as to the purpose of the head on a stay-bolt. The majority found 2½ threads as the proper length to form the head.

W. H. WILSON, THIRD VICE-PRESIDENT.

Mr. Zimmerman—The head of the stay-bolt is of no practical value except to prevent a leak, and we follow up the practice of using about two threads; just enough to hammer over a little and prevent the bolt from leaking.

Mr. Goodwin—Usually we try to make the bolt fit the hole. I think when we get beyond that we are leaving more metal there than needed. The object of driving a bolt is to upset it in the hole, and the more bolt you have on there the less swelling you have. I never considered the head on the bolt very strong in making it tight.

Mr. O'Connor—A short time ago I had occasion to remove in the neighborhood of 140 bolts out of one of our largest engines on account of pulling through the sheet, caused by the small head. It was wholly on account of the small head. In the bad water district the small head on a stay-bolt is not the thing to have. You have to remove them too often.

Mr. McNulty—I think if we have the hole proper the head does not make much difference.

Mr. Lettri—I have noticed sheets corrugate in bad water districts where the hole on the fire-box sheet has been 1/32 of an inch larger on the water side than on the fire side, and if the head wasn't there the bolt would pull out.

President Hempel—The head on a stay-bolt is to retain the factor of safety. You all know that any bolt in a fire-box will lose a percentage of its factor of safety as it becomes old. The sheets will bulge, and if you have no head you have lost that factor of safety.

Mr. D. A. Lucas—My view of driving a stay-bolt is to upset it and make it tight in the hole. When you leave over 2½ threads, it does not upset in the sheet the way it ought to. I would rather it would be less than 2½ than over. When the sheet bulges it injures the bolt. If the head wasn't there the bolts would give way long before they do. The head helps strengthen the bolt.

Mr. Kelley—Has any one ever made a test on pulling stay-bolts with the flush head or no head? How many thousand pounds difference is there between a stay-bolt with no head and a stay-bolt with a head?

President Hempel—It will break the bolt before it pulls out with no head. We have made tests and found that with a ⅜ plate properly secured, the bolt will break before it will pull out of the sheet. They pull out all the way from 28,000 to 34,000. A bolt with a head will not pull out at all..

Mr. Kelly—We have had bolts pull out where the thread would be stripped right off. A test with the stay-bolt flush and hammered, resulted as follows: Test 1. Stay-bolt flush pulled out of plate at 15,000 pounds per square inch, cold. Test 2. Stay-bolt with hammered head pulled out of plate at 18,000 pounds per square inch, cold. The bolt did not break; the head turned inside out. The point I want to bring out is that the head on a bolt is of some benefit.

The committee sent out to determine what papers should be discussed before the convention, reported that the following should be brought up: "Leaky Stay-Bolts," "Flexible Stay-Bolts," "Cracked Door Holes and Flanges."

LEAKY STAY-BOLTS.

Mr. Ryan—In regard to leaky stay-bolts, great care should be taken in tapping out the hole; taps should be kept in good condition and should be cleaned after tapping each hole, so that the borings will not catch and tear the thread. Great care should then be exercised to see that the bolt is properly cut; that is, it should be perfectly straight. Bolts should not be too tight or too loose when put in and set, allowing two threads for the head. A larger head than that allows the bolt to become hot and weakens it. After proper driving we have very little trouble with stay-bolts; if after the engine has been in service for a while the bolts are starting to leak, take light hammers and re-drive them, being sure to hold them on the outer side. If the bolts continue to leak, I would advise that the bad ones be renewed, the hole retapped and a new bolt put in. I do not believe in too large a bolt; keep your bolt as small as possible. After bolts become 1⅛-inch the hole should be bushed reducing the diameter of the bolt.

A great deal depends on water conditions. On some divisions of the Union Pacific we never have a leaky bolt and on other divisions it seems impossible to keep them tight with the best of material and the best of workmanship.

Mr. John B. Smith—Stay-bolts will not leak if put in properly, unless in bad water districts or on account of mud or improper care in washing out. I ntaking care of leaky stay-bolts at terminals, the bolts should be held on and hammered up. Care should be taken not to hammer the bolt too much, as the size of the hole in the fire-box will be increased, and if you have to remove bolts on account of looseness you will find the hole has enlarged from 1/16 to ⅛-inch more than it was in the first place. Another good way to tighten leaky bolts is to take a center punch and holding on the center of the bolt give it two or three blows with a chipping hammer. Another way is to use a fuller and rivet tool.

If bolts are leaking very badly and have been hammered several times they should be renewed, as they are not fit to be in high pressure boilers. If you don't remove them you will find that the sheets will draw heads off stay-bolts. If stay-bolts leak outside of fire-box they should be hammered up, but if leaking through telltale hole they should be renewed, as it is a sure indication that there is a flaw in bolt or is broken off. If stay-bolts leak in corners of throat sheet they should be taken out and flexible bolts applied.

President Hempel called on Mr. J. A. Doarnberger, who said that he did not believe that heat or anything else makes much difference with the stay-bolt. There may be 2, 2½ or 3 threads, but the secret of the stay-bolt proposition is in the proper application; fitting them properly.

Flexible Stay-Bolts.

Mr. D. G. Foley—The Delaware & Hudson Company have 29,183 flexible stay-bolts in service, beginning with the month of February, 1905. During 1905 we had 4,806 flexible bolts applied. During 1906 we had 16,302 flexible bolts applied, and up to the present time, 1907, we have 8,075 flexible bolts applied, making a total of 29,183 flexible bolts in use on the D. & H. system. We have not, as yet, found a broken flexible bolt, or are we having any of them leaking. We have found up to present time that wherever we apply flexible bolts we will not have to go to the expense and delay of holding an engine to renew again in a few months.

We have some boilers with only 50 flexible bolts. These were the first, and were applied on trial. We have since increased this to 450 bolts per boiler. We have found that all the expense there is is in the first application.

Flexible bolts were put in on trial in place of sling stays, and up to the present time have been very satisfactory in every way. These boilers are carrying 200 pounds steam pressure. All boilers equipped with the flexible bolts are carrying 200 and 210 pounds steam pressure.

At first-class repairs the caps are removed from all flexible bolts. Bolts are examined both with wrench and by holding on one end and taping with hammer on the other. We have not, as yet, found a broken flexible bolt. When renewing the ordinary broken stay-bolts, whenever possible, we renew with the flexible stay-bolts.

Mr. Filser—We have been using the flexible stay-bolt for four years on the Big Four, and we have had very good results. We stopped the leaking on the inside. We make a full application.

Mr. James Cooke—We have some engines carrying 225 pounds pressure, and we found that it was absolutely necessary to put flexible bolts down as low as the bend on the boiler. We often found them broken down to the ogee from one end to the other. It is best to put flexible bolts almost over the entire end of a boiler carrying that pressure. On other boilers it is only necessary to put in two rows at the top and two rows at the bottom and fill in the corners. We have not found a broken flexible bolt. We take the caps off and sound the bolts; put some graphite on and put the caps on.

Mr. D. A. Lucas's first experience with the flexible bolt was not successful. They were applied in their first 200-pound engines, in the first two rows and across the top. After a year or two from 5 to 12 or 15 of them were found broken, and the company decided to do away with the flexible bolt. He reported that in the last two or three years they have been applying the Tate flexible bolt in the corners, starting with 25, and later increasing it to 300. After three years service none have been found broken. A little scale forms in the cap, but it is easily knocked out, leaving the bolt free again.

Mr. Hennessey asked how the flexible bolts were tested while the engine is in service, and Mr. Lucas replied that the boilers ran for three months before the caps were taken off the first time, and that it was finally decided to remove them only every two years.

Mr. McNevin—The solid bolt broke first, and we took off our cap and applied the flexible flat-head bolt. By putting in the other bolt between them here and there it helps out.

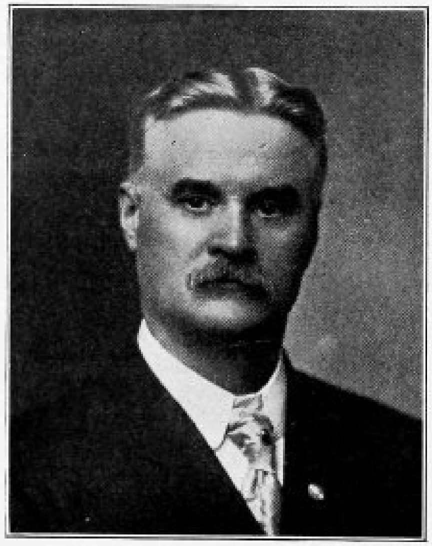
Mr. McCune—If we are going to adopt a flexible bolt why not adopt it all over the fire-box. If you have a flexible bolt all over the fire-box it will adjust itself accordingly.

Mr. A. N. Lucas commented favorably on the flexible stay-bolt, bringing out the fact that all of the roads that are using flexible bolts are also using rigid bolts, making it hard to determine the breaking zone. Eventually it will mean a complete installation to overcome the breaking of bolts.

Mr. Burdett—If we apply the flexible bolt in what we call the breaking zone, does not the bolt next to the ones applied become the breaking zone? If you are going to apply a flexible bolt to the breaking zone I think you will have to apply them all over the fire-box.

Mr. Filser—The installation of the Tate flexible bolt would be the proper thing from the top down, forward and back, in place of sling stays, also bolts with a head on.

Mr. D. A. Lucas—It is the flanges and the rigid part of the sheet that makes the bolts break. Down in the center of the sheet you seldom have a broken bolt. We have had engines built with two rows of flexible stays all the way around and across the corners, and on the outside row all the way around the back head and around the corner, and one of these engines, after running six or seven months, had, I think, five broken bolts in it. The same class of engine without any flexible bolts had 115 broken in it.



E. W. ROGERS, FOURTH VICE-PRESIDENT.

Mr. Lewis—We had an engine come in the shop for a new fire-box that had about 400 flexible bolts, not one of which was broken. It was a large boiler, carrying 205 pounds pressure, and we had to drill every bolt on the inside of the fire-box in order to get them out. I think the flexible stay-bolt is the proper bolt for overcoming the difficulty we have had in the past years on account of broken stay-bolts, and my orders now are to apply the flexible stay-bolt in all boilers carrying 175 pounds pressure or over. They are to be applied down both sides, five rows from each end; five rows from the front end and five rows from the back end, and the third row from the mud-ring up. I am speaking of the Mother Hubbard class of engines with the wide fire-boxes. They are extensively used on the Lehigh Valley. We had some engines come in with T-irons on. I took them off and put in four rows of flexible stay-bolts, and the only defect we feared was that it might not be strong enough on the crown sheet. Some thought we ought to rivet it down, and wherever we riveted it we gave it the same length.

Mr. Cushing—I have been handling boilers with flexible stay-bolts for about fifteen years, and I never found but two of them broken. They had eight bolts in the top corner of the fire-box. I have repeatedly removed the rigid bolts. One engine was sent over to Delaware to have a fire-box put in, and they reported back that after five years none of the bolts in the top corners were broken.

Radial Stay vs. Belpaire Boilers.

The only paper reported on this subject was one written by Mr Cushing, as follows:

This topic is one on which there can be a great diversity of opinion, and I believe that actual experiences covering a period of years will vary greatly. My experience in handling the different designs of boilers and fire-boxes has been such as to cause me to favor the radial stayed boiler.

I have been handling the Belpaire boiler for a period of fifteen years, and in that time I have studied it thoroughly, and

P. F. FLAVIN, FIFTH VICE-PRESIDENT.

have generally found that after the first twelve months the flue holes in the top corners had become elongated one thirty second-inch, necessitating the reaming of same. Before two years the bridges would crack and have to be plugged, flue holes would have to be reamed again, making them two and three thirty-second inches, the flue sheet would also be bulged in the center, making it necessary to apply a new flue sheet. The life of fire-boxes in this design of boiler is from four to four and one-half years. I firmly believe the Belpaire design of boiler cannot be compared to the radial stayed boiler, particularly the modern design of radial stayed boiler, for in the Belpaire there is too much flat surface for boilers carrying 200 and 225 pounds pressure.

The criticism so often heard in regard to radial stayed boilers of "cracking at the top of the flue sheet," is, I believe, due to faulty construction only, and my reason for saying this is that I have paid particular attention to the upward movement of flue sheets, and find that in three years a crown sheet will be bulged up three-quarters of an inch in the center over the flue sheet, while the short radius in the corner of same will be in its natural position, thus putting all the strain due to expansion on the top of the sheet, causing it to crack just above the short radius.

To overcome this I would recommend that the flue sheet be given 2 inches radius when being flanged instead of 1 inch, which I find is the usual practice although in a great many instances it is even less. I applied a flue sheet to one of our large passenger engines carrying 200 pounds steam pressure with a 1½-inch radius at this point, and after twenty months service I applied side sheets to the same engine. There were no signs of fracture in the top of the flange of this sheet, the only noticeable change in this flue sheet being that it was 5/16 inch longer from the bottom flue hole to the top of the flange in the center than when it was applied, making the crown sheet appear as if the engine had low water.

I would also recommend the use of Tate flexible bolts or some other bolt of like design all over the crown sheet and down to the third row below the parallel seams of the fire-box, thus giving free expansion room to the fire-box when the engine is being fired. I think these two changes would not only increase the life of our fire-boxes but also the life of our flues, as it would stop the buckling of flue sheets which now causes so much trouble with leaky flues in the bottom of the sheet.

J. R. CUSHING.

Mr. D. A. Lucas—The Belpaire boiler in my locality, the C., B. & Q. west of the Missouri River, is by far the best boiler, as it is cheaper to maintain and is a great deal more serviceable. We have had Belpaire boilers in service sixteen years without the renewal of the fire-box; also the crown stays last from six months to a year longer without renewal than in the radial stay boiler. The average life of a fire-box in a radial stay boiler is from two years and six months to four years in boilers carrying from 160 to 200 pounds pressure.

The life of the back flue sheet in a radial stay boiler, with the flue hole 2 inches in from the heel of flange to center, was as short as five months when it had from two to four cracks from flue hole to rivets, and we began removing them when they were six months old, while the Belpaire sheet will last from two and a half to three years without giving any trouble. We have removed an average of six flue sheets from radial stay boilers to one from a Belpaire. The boilers in our locality cover a large territory, and in the bad water district, where the water is of a foaming nature, the Belpaire carries the water much better than a radial stay boiler.

Mr. Morrison—I take exceptions to the paper in this respect. Where I am located we have ten of the Belpaire boilers, and the only dissatisfaction that we find with them is in the shoulder sheet outside. We get better than twenty-one months service out of the engine; the water is, however, exceptionally good.

Mr. D. A. Lucas—The Belpaire side seams never give us any trouble, while it was a pleasure to keep the side seams in the radial stay from leaking, and the crown stays in the Belpaire boiler do not have to be removed near as often as in the radial stay boiler.

Mr. Laughridge—I would like to ask if you do not have trouble in the radial stay with the outside row, finding the hole cracked on the water side. With the Belpaire boiler we can leave the crown sheet in, and it will run two sets of side sheets, flue sheets and door sheets.

Mr Lettri—I think you will find trouble in the radial stay boilers where the row of stay-bolts comes into the crown sheet.

Mr. Hennessey—Where the fire-boxes are in three sheets we have trouble with the seam. A new engine may come in inside of four or five months with the rivets commencing to work and they have to be removed. They crack around the flue hole, around the flange up to the rivet hole. He exhibited a sample of heavy scale taken from between the center stays on a radial stay boiler.

How To Overcome Cracked Door Hole Flanges.

Mr. D. G. Foley—The Delaware & Hudson Company have 471 locomotives on their main lines; 328 of which are of the Wooten type, which have an oblong door 12½ inches by 36 inches. The bottom of this door hole is only 7 inches above the top of the grates. It will be readily seen that this door hole flange is subjected to a constant strain of expansion and contraction, since it is so low, and partly covered with fire.

After our Wooten type of boilers are in service eight to ten months our troubles commence with the door hole flange cracking on the bottom. These cracks start at the heel of the flange or knuckle; being only about ½ to ¾ inch long when they begin to leak. We then plug them. These cracks gradually work into the rivet holes in the flange and down the door sheet.

Finally, after being in service about fifteen months, a patch 7 by 28 inches has to be put on the bottom. After the boiler is in service about 2½ years a patch has to be put on top of the door hole. The patches have to be renewed after being in service as long as before being patched, as they crack in the heel of the flange just the same as the original sheet. These cracks are not due to mud or poor water, for we have very good water.

We can get from 80,000 to 100,000 miles out of a full set of flues, and about 45,000 miles before renewing the lower ones. Our fire-boxes last from 10 to 12 years, and we run 40 days or about 6,000 miles between washouts. I have not as yet found a case where our door holes were mud bound, or any cause for our door holes cracking, other than expansion and contraction.

In order to overcome the expense, delay in holding engines in shop for repairs to door holes, and engine failures due to door holes leaking, since May 1, 1906, we have equipped fifty-one of our Wooten type boilers with the O'Connor improved door-hole flange. They are scattered all over the D. & H. system, and are in all kinds of service. They have not, as yet, cost one cent for repairs to the door-hole, nor developed a defect of any kind. The principle of absorbing the expansion seems to be correct.

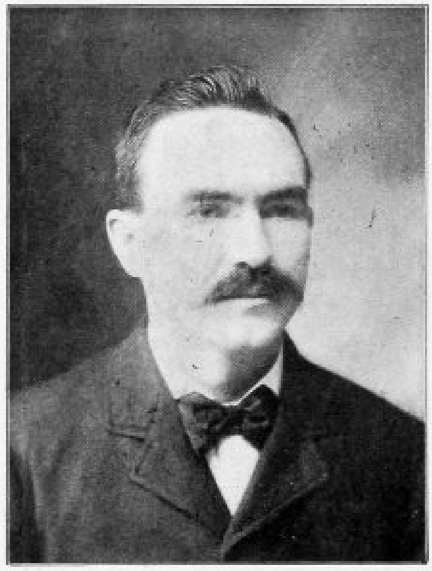
Mr. O'Conners—I commenced experimenting with this door about 1900. We have now on the Northwestern system, during the past four years or over, more than 400 locomotives equipped with this door, thirteen divisions all told, and we have never yet applied any expense whatever to them. In the year 1902, while I was experimenting with this door I notified the boiler makers west of the Missouri River to keep an accurate expense account of the labor and material that was expended on these flanges alone. They sent it in from time to time, and at that time we had 104 engines on that division, and the average expense on a locomotive during that year was $13.57; $13.00 per locomotive from the defect of the door alone; what could we figure on a railroad having 1,000 or 1,500 engines? We have satisfactory reports from the railroad managers and superintendents of motive power that have used the door. On the Great Northern system they have about the hardest water of any road in the country. Mr. Emerson, the superintendent of motive power, applied one of these doors three years ago, in September, and a short time ago he reported to us that he was going to equip twenty of his locomotives. The M. K. & T. are applying them to all their shop engines—all engines going through the shops for general repairs. The D. & H. has fifty-one on and twenty-five more ordered. Others have ordered, and it is giving entire satisfaction and eliminating the cracking of doors.

President Hempel—I watched very closely the results obtained by the Northwestern from using the O'Conner door, and found that it practically did away with the cracking of the door. We should have some way of overcoming the cracking of fire doors, and I know of no other way except through some such means; by increasing the flange to a larger radius, making it more easy and giving it a better circulation. That is the way I understand the door.

Several others, including Messrs. Smith, Lucas, Doarnberger, Kelly and German, reported that they had used the O'Conner door and that it had given good satisfaction.

Mr. Flavin—Some one alluded to a patch. I will say that I never saw a fire-door cracked on the bottom in my life. Why should the patch cover the bottom of the door? I have probably applied a thousand door patches on roads where fire-boxes last twenty months, flues last ten weeks; where it was bad water and cold weather, and the entire door-collar patch is wrong. While you do have to flange, providing there are six or seven rivets left, the patch gives better satisfaction without covering the lower section of the door. I do not know whether it is a matter of expansion or not, but a fire-door collar that includes everything but five or seven rivets on the bottom will undoubtedly give better satisfaction. The O'Conner door has covered all of these matters.

President Hempel—It seems to me as though a patch applied as you mean, leaving a part of the metal on the bottom, would be better than to take out the entire door hole.



FRANK GRAY, TREASURER.

Mr. O'Conner—Another point I wish to make is that the O'Conner door can be applied to any locomotive regardless of the shape or form of the door without any change in the back head. If the head is changed there is a considerable amount of labor and expense.

It was suggested by Mr. Flavin that the subject of boiler explosions be discussed, but as no papers had been prepared on this subject, President Hempel advised that it be brought before the next convention. He then appointed Messrs. Cavanaugh and A. N. Lucas as a committee to audit the books of Secretary and Treasurer Goodwin, after which the discussion of "Shop Practices" was opened.

Shop Practices.

It was moved by Mr. Hennessey that before the convention adjourn it take into consideration the question of the maintenance of flues while the engine is in service. The motion was carried, and the president appointed Mr. Hennessey and Mr. Burdett as a committee to prepare a paper on this subject.

Mr. Kelly—How far should the flue hole be spaced from the flange on top of the radial stay boiler; Belpaire or circle top?

Mr. Flavin—By eliminating the center of the flue hole my experience is that the further you can place the upper edge of the flue hole from the knuckle edge of the sheet, the better service the flue sheet will give. I think it should be 2⅜ from the knuckle of the flange.

Mr. D. A. Lucas—Our practice is 3 inches for a 2-inch hole and 3½ inches for 2½ inch. With new flue sheets, where the flues are already in, we leave out 25 flues around the outside edge of the sheet and plug the front flue hole, but we do not put a hole in closer than 3 inches.

Mr. Flavin—I find that in Belpaire boilers if you exceed 2 inches it has a tendency to crack, and instead of cracking from the flue hole around the knuckle of the sheet it shows a horizontal crack. I think that 2⅜ inches from the outer edge of the flue hole is now the limit.

THURSDAY MORNING SESSION.

President Smythe called the meeting to order, and a paper* by Mr. Morrison on flue welding and setting was read by Mr. Clark.

A FEW OF THE LIVE ONES.

Mr. Lester—What success do you have driving stay-bolts with a long-stroke hammer?

Mr. Lucas—We have until lately been driving our stay-bolts with an 80-pound hammer, nothing over, and get good results, driving 800 ends in 10 hours. We have a gang outside and a gang inside, and use a riveting die with a center in it 2½ or 3 threads, dropping the die into the center of the bolt. We have had them in three years' service now and they do neat and rapid work. We use an air holder-on with a flat die or stay-bolt die, and use 100 pounds air pressure. I have been using this same die for two years past, and apply all the bolts in new boxes with the same stay-bolt die. I use a No. 5 Boyer, which upsets them well. I have made tests, driving them one side by hand and the other side with a hammer and die, and the result is in favor of the die-driven bolt. It upsets and crowds it into the hole better than by hand. The only thing to be particular about is the length of the bolt; it must not be too long for the die. I have a gage which is slipped over the ends so that the two stays hit the sheet. We lay our boilers down and drive all down-handed, with a couple of horses on each end; one man stays at one end of the box with the holder-on, and one in the center with the hammer, and they work away from each other. The bolts are partially cut to length in the machine and broken off inside after they are screwed in. All bolts have tell-tale holes drilled 1⅛ inches deep but are solid inside, and so do not split.

The following report on maintenance of flues was read by Secretary Goodwin:

Maintenance of Flues in Service.

The committee appointed by you on the subject of the best method of applying flues, also the best method of maintaining same while in running service, both on the road and at terminals, would like to have each and every boiler foreman give his experience as to the best methods and best tools to be used to get the best results. Knowing that every railway official on all railways at the present time are deeply interested in this subject, and believing that they have their eyes on this convention, we believe we can all of us derive a great amount of benefit by listening to the experience of others, and would recommend that this subject be opened for discussion.

E. J. HENNESSEY, N. Y. C. R. R.
T. BURDETT, C. & N. W. R. R.

Mr. A. N. Lucas—I believe the hole should be smooth; the burr should be taken off on both sides; the copper should be put in flush with the fire-box side; it should come in with a tight fit and not have to be driven with a swedge. It should be put in just far enough back to allow the bead. To hold the shim in position it is well to turn the bead over; take the face of the hammer and hit it a few blows. When the last flue comes in they are all ready for expanding. Turn the expander four times half the width. You are not working your sheet half as hard if you use a 5 or 6-pound maul. I believe we ought to work from the elbow and not take the body swing at all. We bead our flues, using no roller. We use a backing hammer, turning the expander twice or three time; always going light on it. We are getting better than 100,000 miles, and we have got as high as 230,000 miles in our heavy passenger service, with two or three years service between flue renewals.

The greatest trouble we have in boiler work is the care of the flues in the round house. Too much attention cannot be paid to working the flue in the round house. We claim that we should use an expander some shorter on repair work so that it will go in the original recess to the first setting which will tighten the flue in there as well as in the back.

We take very good care of our boilers at terminals, in the round houses and on the road. We use considerable soda ash, and we seldom find scale between the flue. We have six wash holes and wash from the front end, over the crown sheets.

Mr. Cavanaugh—What is meant by retubing? Possibly Mr. Lucas has been applying two V shapes. We are running locomotives, but we are not getting any such mileage as that. Possibly we could get 200,000 miles out of the top flues.

Mr. A. N. Lucas—It is not our practice to recommend a half set of flues. We get as high as thirty months' service before we take a flue out of the boiler. If we take out more than forty we pull the flues. We do not make a practice of renewing the bottom flues at all.

Mr. Tejnan—We have had experience with the steel tube. The best we could do in bad water districts was three to four months with the iron flue; with the steel flue we got from five to six or seven months. The water is bad.

Question—How do you find the pitting on steel flues?

* This paper will be published in full in a subsequent issue.

Answer—We do not use the entire steel flue; just use the steel ends.

Mr. A. N. Lucas—We have considerable pitting with the iron flue. The last few years the iron flues pit considerably. Tests show that there is some steel in them; they are semi-steel.

In reply to questions Mr. Lucas stated that he allowed a scant quarter inch for the bead and used a prosser expander with a shoulder on it for new work.

Mr. Green—I believe the life of a flue depends largely on the thickness of the sheet. I have found that engines with 5/8 flue sheets would run possibly four months, and then begin to burn the beads off, and in the same district a 1/2-inch sheet would run longer. It is not so much in setting the flues because most everybody uses a prosser expander.

Mr. D. A. Lucas—I have had considerable experience with flues and have treated them different ways. Our present method is filing the flue hole through a radius of 1/16 of an inch on each side and applying a copper ferrule flush with the sheet on the fire side. We use an inch long shim.

I would like to ask whether the flue leaks between the flue and the copper or between the copper and the sheet? I made an examination once and found that it leaked between the copper and the flue. With a long shim the copper shim is rolled into the sheet and the flue swedged 1¼ back, and it makes a nice dry fit. When the cold air hits the flue and strikes it in the sheet proper, I did not experience the weeping of the flues that I did with the narrow shim.

When they put the engine into the round house to give it a final touching up, I have the flues rolled lightly and calked, and we have practically stopped the flue trouble. We are in a bad water district where the flues won't run over a year on account of pitting. We are using the Tyler tube for our iron tube, and we have had several test sets of steel tubes with good results.

Mr. A. N. Lucas—A great many times in doing round house work, the flues leak badly and quite often the boiler maker gets instructions to go after them hard. The harder they go after them the worse the results. They crack the bridges and pull the flue sheets out of shape. You cannot work a flue too lightly; just work it in the sheet and do not work the sheet itself.

Mr. Lewis—I went to the Lehigh Valley last January and found conditions similar to what Mr. Hennessey spoke about on the New York Central, and I went into the question of the tools the men were using. I found them all using the roller expander, and they were rolling and rolling and rolling. They kept a record of what engines they had worked on and everything had been rolled.

I reported to my superior officers that the practice would have to stop if they wanted to maintain the life of the flue. I said, "Take the rollers away from the men and give them a prosser tool, and see that they are furnished with the proper beading tools." After discontinuing the use of roller expanders in round house work, the reports concerning engine failures have been very encouraging.

I think the proper tool to be used to maintain the life of the flues is a prosser tool, one with the shoulder on and one with the shoulder off.

I might say that I have changed the method of applying flues. I have put into practice the same method as Mr. Lucas uses, with the exception that he does not roll the flues. I believe that when we first apply the flues we ought to give them a light rolling after the prosser has done its work. Old flues, which had been rolled thin, occasionally burst when prossered, but new ones never did.

Mr. Lester reported a similar method of applying flues in vogue on the Erie.

Mr. Plowman—We have eighteen or twenty extremely wide fire-boxes, and the greatest trouble is in the flue sheet bulging at the bottom. We put in a set of flues and they run from four to seven or eight months when the flue sheet will bulge as much as 1⅝ inches at the bottom. We adopted the plan of leaving out the open space of flues and bracing them 1¼ inches. We find that the life of our flues is from seven to eight months longer with our flue sheets braced.

Mr. T. J. Morrison—There has been a great deal said about flue setting, but there is as much in taking care of the flues after they are set in the boiler as there is in the setting. We take them out and clean the flue holes out—clean out the dirt which accumulates. We drive them tight and roll the flues lightly after we put them in; then I have them laid over with a hammer, and when the man is laying them over I have them rolled in the front end before I have them expanded in the back end. And then we bead them.

In regard to the engine after it goes out. There is a great deal in the care that the fireman will give an engine on the road. Some firemen and engineers will get better service out of their flues than others, because they keep their fire level. If more care were taken of the engines at the terminals and more care taken of the boilers at washouts it would be better. We have been able to dispense with one boiler maker on repairs. We blow off the boiler through the pipes, wash with hot water and fill the boiler again with hot water. The flue sheet and fire-box is never cold, and we do not have much trouble with flues or cracked side sheets. I thought at one time that there was nothing like rollers, but we now use a prosser expander. When a flue is rolled too often it stretches and becomes thin, and you do not have enough material to work on to keep it tight. Since we have been using the prosser we get from eight to nine months out of the lower half, then we take out about 100 or 125 and renew them on the bottom.

Mr. Flavin—It is one of the greatest mistakes to roll a flue after it is prossered. Twenty years ago, at the International Railway Exhibit, I had charge of the flue demonstation of the C. & A. road. The first flue was rolled and beaded; the next was prossered and beaded, the next was prossered and rolled and beaded, the last was prossered, beaded and then rolled. We found in the case where the flue was prossered and beaded the joint on the fire side was perfect, but there was no joint between the edges of the sheet. In the case of the flue that was prossered and then rolled we found that the entire labor of prossering the flue was wasted. The flue that was rolled and then beaded showed a very pronounced joint on the fire side, but not nearly so pronounced a joint on the water side. The taper end of the flue on the fire side will roll more than on the inside. After that the practice was to roll the flues lightly, then prosser and bead. Another objection to the roller is that the copper ferrule is put in there on account of its being fibrous, but I have visited shops where the roller is used to such an extent that the copper ferrule is entirely useless. The roller should never be used hard, and after the flues are once in service the roller should never be used on them unless it is absolutely necessary.

There should never be a given limit to the length of the flue to be turned over because the flue bead has one more thing to do when it stops a leak and that is to brace the sheet.

There is no excuse to-day for a plugged flue. If it is bursted it should be removed, which is a very simple matter. I believe the ferrule should be exactly the same thickness as the sheet.

Another thing to be considered is the size of the nozzle. With a self-cleaning front end it is wrong to apply a set of nozzles so small that the entire draft of the fire-box goes in every time the fireman opens the door. We will never solve the flue proposition until we solve the nozzle proposition.

President Smythe—You have noticed in many cases in beading a flue that it would lap a burr on the inside; you would not use a roller expander; would you recommend that in order to get rid of that bead that you use a prosser expander?

Answer—Use a prosser expander, if the water is of such a nature that the flue has not begun crystallization. The lightest hammer made should be recommended for the use of rebeading flues.

The greater the number of flues the greater the bridge should be. Another fact is that the upper row is so close that they crack from the top of the flue hole to the center of the rivet hole. They put a plug in them and there is a stream of water that gets the other flues to leaking and they tie them up.

I scarf the sheet down to the knuckle of the flange and apply a ¼-inch patch very light, drive and countersink. To cut out the top knuckle of the flue sheet destroys the resistance of the sheet.

Mr. Kelly—We argue this flue question back and forth. What I think we ought to get at is some standard practice. We should pass upon these things and take a vote.

I try to keep the flue holes on the top down. I cut the burr off on both sides and use 40-pound copper. If I can increase the bridge to ⅞ of an inch, I do so. I lay out all my flue holes to increase the water space. I leave out five flues in small engines and nine in large engines. The flue is swedged down to about 1 inch. We expand good and hard with an air hammer. We expand two rows straight across. I do not believe in starting at the bottom of the flue sheet with any kind of a hammer. If you do not stay the flue sheet you will have trouble.

We use 3/16 and have a standard beading tool. I have no use for the roller at all except in oblong holes. A prosser expander in the round house is all right; and I believe it is the only method.

We may exercise all kinds of care in the shop, but the man with the injector and the fireman with the shovel can stop the perfect circulation of water. We should recommend purified water no matter how it is obtained. I claim that bad water, together with the fact that the engineer will work an injector at the wrong time and poor firing has as much to do with flues leaking as anything. It is our fault just the same. We should get after these things, point out the mistakes and when we get on record there will certainly be some action taken.

Mr. Stewart—Something should be done on the inside of the boiler. We are using a water pocket which puts the water over the top of the flue. This has not been in service long enough, however, to recommend it.

Mr. D. A. Lucas pointed out the damage done by blowing the cold air on the flues, and then told of an instance of flue trouble where the engine had a ⅝ copper ferrule applied in the sheet without the edges of the hole being filleted. It was just as it came from the drill press, and in expanding the flue with the prosser expander it cut the copper ferrule off on the inside flush with the sheet, spoiling the joint made on the copper with the shoulder of expander. It was impossible to keep the engine from leaking. The flues were reset, filleting the holes, using the same width of copper, and the flues worked with the same process, prosser expander and beader as previously, after which the engine made 96,000 miles without any delays on account of leaking flues.

Mr. Flavin moved that a committee be appointed to make a full report on this topic at the next convention. The motion was carried and President Hempel appointed the following committee: E. J. Hennessey, Frank Gray, D. A. Lucas, T. S. Morrison, F. J. Kelly, B. F. Flavin and T. W. Lowe.

THURSDAY AFTERNOON SESSION.

President Hempel called the meeting to order at 2 P. M., and announced that Mr. Wagstaff, as chairman of the executive committee, was ready to report.

Mr. Wagstaff—I will say in reference to the by-laws and constitution. You are aware that the time was limited in which to take up so many subjects, one after another. It was pretty hard for the committee to make up their minds, and it is quite possible that there may be some articles that were not thought of, but I think we have covered it sufficiently until we can have time to think it over and see whether it needs any revision or not.

The report of the executive committee was then read and accepted, and a vote of thanks tendered the committee for their faithful services.

President Hempel—You have the whole year to look over the resolutions and bring up any amendment at the next meeting.

Mr. Slate—In March the Champion Rivet Company offered three prizes to the ones who would submit the best article on the subject of driving steel rivets. The first prize was $50, the second $35 and the third $25. The papers were closed May 1 and all sent in under nom de plumes, the judges not knowing who had written them. I have the pleasure of announcing that the first prize has been awarded to James Crombie, of Hamilton, Ontario; the second to James T. Goodwin, of the American Locomotive Works, Richmond, Va., and the third to Thomas C. Best, of the Jos. T. Ryerson Company, Chicago.

These papers will all be published in a future issue of THE BOILER MAKER.

President Smythe—If I am not out of order I would propose three cheers for the winners. Three lusty cheers were given.

The secretary read the following communication:

We the members of the Ladies Auxiliary wish to express our grateful appreciation of favors shown us during our stay in Cleveland. During the past year the recollections of our Milwaukee trip have lingered with us, and we are quite sure those of Cleveland will linger not only for one year but for many years.

Realizing as we do that these conventions would not mean much to us were it not for the splendid entertainment furnished by this association, we take this method of returning our thanks for all courtesies extended in the hope that they have been equally beneficial to both organizations.

Respectfully submitted,
MRS. W. H. LAUGHRIDGE,
MRS. J. H. SMYTHE,
MRS. A. N. LUCAS.

Secretary Clark, of the M. S. B. A., reported 14 associate members, 319 active members, in good standing 198 and in poor standing 124, new members during the past year 54.

It was moved and carried that all members not in good standing should not be entitled to vote. Carried.

ELECTION OF OFFICERS.

The convention then proceeded to the election of officers.

Messrs. Goodwin, Hennessey and Wagstaff were nominated for president. Mr. Hennessey withdrew in favor of Mr. Wagstaff. The ballot resulted in favor of Mr. Wagstaff, and it was moved by Mr. Goodwin that the election of Mr. Wagstaff be made unanimous, which was duly carried.

Mr. Wagstaff in accepting the office said: "During the past year I have been busily engaged in working for this association, and, regardless of the honor that has been conferred upon me this afternoon, the culmination of the work of bringing so many of us together would be sufficient to make me delighted. I assure you that I can only do one man's work, and it will be my great pleasure during the coming year to transact the business in as good a manner as it is possible for me to do. The organization is not what we would like to see it; it is not what we expect it to be, but we must remember that we are young and have a long time in which to grow. Let us hope that during the coming year the advancement of this organization will be such that it will not only reflect credit on your president, but upon all the officers who may be elected and the members. I thank you very heartily for the unanimous election, and I assure you that I will fill the office to the best of my ability."

For first vice-president the names of Messrs. E. S. Fitzsimmons, E. W. Rogers, Mr. Patrick, E. J. Hennessey and E. P. Cavanaugh were placed in nomination. Messrs. Patrick, Cavanaugh and Hennessey declined the nomination in favor of Mr. Fitzsimmons, and the ballot resulted in favor of Mr. Fitzsimmons.

It was moved by Mr. Rogers that Mr. Fitzsimmons be declared the unanimous choice of the convention for first vice-president, which was accordingly done.

E. J. Hennessey, W. H. Wilson, E. W. Rogers and P. F. Flavin were unanimously elected second, third, fourth and fifth vice-presidents, respectively.

The nominations for secretary were J. T. Goodwin and Harry D. Vought. In nominating Mr. Vought, Mr. Wagstaff said:

"There is no man holding a position the same as all our members are holding who has the necessary time to devote to this large association. You should not forget that we are a double-header. Mr. Vought is a man who makes his living by being secretary. He has been the successful secretary of the New York Railway Club, which has a very large membership, for several years. He is secretary of the Central Railway Club, which meets in Buffalo, and from a very small membership, it is now one of the most progressive railway clubs in the country. He can give his whole time to this association if it requires it. To enable me to bring his name before the convention it was necessary for me to find out what terms Mr. Vought would accept. If we so desire he will serve this association for 75 cents per member. If we choose to allow him to handle the proceedings he will give each member a copy free, providing you allow him to get the advertising necessary to make the proceedings a success. And if it is the wish of this association to have the proceedings sent broadcast, which I think ought to be done, he is willing to present every member of this organization a copy of the proceedings and 25 percent of the net profits shall be returned to the association and placed in its treasury.

I ought to say that this offer is not from Mr. Vought's solicitation. Those in the room who know Mr. Vought know him to be an active man, and that he is well thought of. He is making a good living and doesn't have to come begging any position; but I believe that we are stepping up into a larger field where we ought to be on a par with the large associations in the country, and it is necessary above all other things to have a good competent secretary who can meet the requirements without sacrificing the position which he holds."

Mr. Goodwin withdrew his name in favor of Mr. Vought, who was unanimously elected.

Mr. Gray and Mr. Bennett were nominated for treasurer. Mr. Bennett withdrew his name in favor of Mr. Gray, who was unanimously elected.

It was suggested that the question of subjects to be discussed at the next convention be left in the hands of the president, after which the convention adjourned to meet in Detroit in May, 1908.

Among those who attended the convention were the following:

Geo. F. Wood, Philadelphia Iron Works, Philadelphia, Pa.; Thos. Oliver, D. & M. Ry., East Farms; A. E. Adams, High Springs, Florida; F. A. Linderman, M. C. R. R., Jackson, Mich.; Charles Hyland, M. C. R. R., Michigan City, Ind.; Fred W. Blume, Scully Steel & Iron Company, Chicago, Ill.; F. L. Lottes, B. M. Erie, Cleveland, Ohio; E. S. FitzSimmons, G. F. B. M. Erie, Meadville, Pa.; F. C. Best, J. T. Ryerson & Son, Chicago, Ill.; W. H. Hanghridge, H. V. Ry., Columbus, Ohio; Chas. P. Patrick, New Jersey Boiler Company, Boonton, N. J.; R. W. Clark, N. C. & St. L., Nashville, Tenn.; E. P. Kavanaugh, B. & O. R. R., Baltimore, Md.; F. J. Sullivan, I. C. R. R., Freeport, Ill.; Jno. E. Stokes, I. C. R. R., Clinton, Ill.; Jno. B. Smith, P. E. L. E., McKee's Rocks, Pa.; Peter Eck, I. C. R. R., Mattoon, Ill.; C. Dave, Cleveland, Ohio; G. B. McElvoy, S. A. L. R. R., Savanah, Ga.; Hugh Smith, Erie R. R., Jersey City, N. J.; Frank Daly, Lidgerwood Company, Brooklyn, N. Y.; Jno. Pages, Newman, Ga.; Wm. M. Zimmerman, Covington, Ky.; F. L. Mallmans, Trenton, N. J.; Jas. J. Fletcher, Toronto, Ont.; H. B. Brooks, Lackawanna Steel Company, Buffalo, N. Y.; Geo. Slate, H. S. Moss, THE BOILER MAKER, New York City; Robert Brown, C. P. R. Winnepeg, Can.; Joe McAlliston, D., L. & W. Ry., Buffalo, N. Y.; T. A. Jameson, Southern R. R., Knoxville, Tenn.; J. Nicholas and wife, Ft. Scott, Kan.; J. W. Schanz, Bridgeport, Conn.; Geo. Wagstaff, N. Y. Central Ry., Buffalo, N. Y.; M. O'Connor, C. & N. W., M. O. Valley, Iowa; W. Plowman, Big Four, Urbana, Ill.; A. N. Lucas, C., M. & St. Paul. R. R., Milwaukee, Wis.; J. H. Optenberg, Optenberg Iron Works, Shihaygan, Wis.; C. L. Hempel, 2522 Davenport street, Omaha, Neb.; Miss Hazel P. Hempel, 2522 Davenport street, Omaha, Neb.; J. R. Cushing, Bellefontaine, Ohio; W. H. Hopp, Dubuque, Iowa; J. C. Halladay, Chicago, Ill.; W. C. Cutler, Bethlehem, Pa.; G. P. Wehling, Rome, N. Y.; J. D. McWeirie, Indianapolis, Ind.; C. E. Lester, Erie R. R., Meadville, Pa.; Chas. Kraus, Big Four, Delaware, Ohio; Thos. Lewis, L. V. R. R., Sayre, Pa.; E. W. Young, C., M. & St. P. R. R., Dubuque, Iowa; Thos. P. Green, St. Louis, Mo.; Wm. H. Dem, C., C. & G., Peru, Ind.; C. E. Waite, F. E. C., Florida; D. G. Foley, G. F. & B. I. D. & H. Company, Green Island, N. Y.; H. Morrison, Rock Island Lines, Cedar Rapids, Iowa; C. Ran, V. P., Omaha, Neb.; L. R. Fedler, Rock Island Lines, East Moline, Ill.; C. R. Kurrach, C., I. & S., Kankakee, Ill.; John Harthill, L. S. & M. S. Ry., Elkhart, Ind.; F. A. Batehman, L. S. & M. S. Ry., Elkhart, Ind.; Thos J. Reddy, C. & E. I., Danville, Ill.; W. S. Cozad, Erie R. R., Meadville, Pa.; J. W. Kelly, C. & M. Ry., Chicago, Ill.; Jas. E. Cooke, Greenville, Pa.; E. J. Hennessy, DePew, N. Y.; B. F. McGraff, Oswego, N. Y.; E. Noud, Middletown, N. Y.; A. C. Dittrick, Soo Line, Winnepeg, Can.; F. L. Moser, K. & M. Ry., Middleport, Ohio; E. A. Miller, N. Y. C. & St. L. R. R., Cleveland, O.; J. A. Doamberg, N. & W. Ry., Roanoke, Va.; H. C. Wratton, Racine, Wis.; H. J. Rape, Waterloo, Iowa; J. L. Meyer, Dennison, Ohio; Warren C. Rogers, Cleveland, Ohio; C. R. Bennett, Logansport, Ind.; Chas. Letter, Columbus, Ohio; T. H. Price, Chicago, Ill.; Jas. Crombie, Hamilton, Ont., Can.; H. German, 368 Chicago avenue, Kankakee, Ill.; J. T. Goodwin, Richmond, Va.; W. W. Wilson, I. C. R. R., Chicago, Ill.; Mrs. W. W. Wilson, 2941 Vernon avenue, Chicago, Ill.; J. H. Smyth, 284 Totowa avenue, Paterson, N. J.; A. E. Brown, L. & N. Ry., Louisville, Ky.; M. T. Haran, foreman, B. M., B. & O. R. R., Phildelphia, Pa.; D. J. Champion, Champion Rivet Company, Cleveland, Ohio; T. J. Morrison, Valley Junction, Iowa; Thos. W. Lowe, Canadian Pac. Ry., Winnepeg, Can.; C. F. Wilde, M. O. R. R., Jackson, Tenn.; L. M. Stewart, F. B. M., A. C. L. R. R., Sanford, Fla.; C. J. Murray and wife, Erie R. R., Meadville, Pa.; L. B. Carr, C. & A. Ry., Bloomington, Ill.; P. J. Conrath, Mo. Pac. R. R., St. Louis, Mo.; E. C. Cook, Chicago, Ill.; J. Stevens, Canton, Ohio; Edward B. Day, "Railway Review," Pittsburg, Pa.

The Boiler Makers Supply Men's Association.

The meeting of the Boiler Makers Supply Men's Association was called to order at 9.00 A. M., Tuesday, May 21, with President Williams in the chair.

The reports of the secretary and treasurer were read and accepted.

It was voted that in future, where contributions exceeded the essential and necessary expenses, no rebates would be made, but any surplus funds would be deposited with the treasurer, to be applied on next convention expenditures, or for such other purposes necessary to promote the interest of the association.

The program arranged by the entertainment committee was then read by Mr. Slate as follows:

TUESDAY, MAY 21.

Afternoon—Carriage ride for ladies; leave hotel at 2.00 o'clock; Superior entrance.

Evening—Social gathering in Assembly Hall at 8.00 P. M.

WEDNESDAY, MAY 22.

Morning—Automobile ride for ladies; leave hotel at 10.00 o'clock; Superior entrance.

Afternoon—Euclid Avenue Garden Theater; Wm. Farnam in "Ingomar"; leave hotel at 1.30 P. M.

Evening—Keith's Theater, vaudeville; leave hotel at 7.45 P. M.

THURSDAY, MAY 23.

Morning—Reserved for visiting shopping center or any points of interest.

Afternoon—Colonial Theater; "Soldiers of Fortune"; leave hotel at 1.45 P. M.

Evening—Banquet and ball.

The election of officers resulted as follows:

President—Thomas Aldcorn, of the Chicago Pneumatic Tool Company.

Vice-President—B. E. D. Stafford, manager, Flannery Bolt Cmpany.

Secretary-Treasurer—George Slate, THE BOILER MAKER. (It was moved and carried that the two latter offices be combined under the care of one officer.)

Chairman of the Executive Committee—S. F. Sullivan, of the Ewald Iron Company.

Many handsome souvenirs were distributed by the supply men, including a pearl handle Keen Kutter Knife from the Standard Railway Equipment Company, of St. Louis, Mo.; a match safe from the Chicago Pneumatic Tool Company, of Chicago, Ill.; a Lufkin steel pocket tape from the Flannery Bolt Company, of Pittsburg, Pa.; an album containing photographs of the officers of the two boiler makers' associations, from the Talmage Manufacturing Company, of Cleveland, Ohio; and rubber balloons from the American Locomotive Equipment Company, of Chicago.

The program of entertainment quoted above was successfully carried out, and the work of the supply men was much appreciated by all who attended the convention.

The leading manufacturers and supply houses were represented as follows:

Bourne-Fuller Company, Cleveland, Ohio, W. J. Fleming, J. Hall.

Shelby Steel Tube Company, Pittsburg, Pa., H. S. White, H. A. Flagg, C. H. Wood.

Hanna Engineering Company, Chicago, Ill., E. E. Hanna, C. W. Ellis.

Joseph T. Ryerson & Son, Chicago, Ill., T. C. Best.

Flannery Bolt Company, Pittsburg, Pa., B. E. D. Stafford, Harry H. Pike, Tom Davis, Rogers Flannery.

W. H. Dangel & Company, Chicago, Ill., W. H. Dangel.

Detroit Seamless Steel Tube Company, Detroit, Mich., R. B. Owen.

Ajax Manufacturing Company, Cleveland Ohio.

Cleveland Punch & Shear Works, Cleveland, Ohio.

Seamless Tube Company of America, Pittsburg, Pa., C. R. Phillips, P. H. Furgeson.

Homestead Valve Company, Pittsburg, Pa., P. L. Rhodes.

Spencer Otis Company, Chicago, Ill.

Ashton Valve Company, Boston, Mass., Columbus Dill.

J. Faessler Manufacturing Company, Moberly, Mo., J. W. Faessler, F. E. Palmer.

F. F. Slocomb Company, Wilmington, Del.

Scully Steel & Iron Company, Chicago, Ill.

Chisholm & Moore Manufacturing Company, Cleveland, Ohio.

Cleveland City Forge & Iron Company, Cleveland, Ohio.

Standard Tool Company, Cleveland, Ohio.

Talmage Manufacturing Company, Cleveland, Ohio, J. G. Talmage, E. H. Janes, J. F. Walker.

Champion Rivet Company, Cleveland, Ohio, David J. Champion.

W. M. Pattison Supply Company, Cleveland, Ohio.

Bethlehem Steel Company, South Bethlehem, Pa., J. C. Halladay.

D. T. Williams Valve Company, Cincinnati, Ohio.

Cleveland Pneumatic Tool Company, Cleveland Ohio., H. S. Covey, Fred Conley, L. W. Greve, Arthur Scott, J. F. Graves, C. J. Albert, George Hall.

Upson Nut Company, Cleveland, Ohio.

Basset Pressley Company, Cleveland, Ohio.

Allegheny Steel Company, Pittsburg, Pa.

Brown & Company, Pittsburg, Pa., J. W. Williams.

Worth Bros. Company, Coatesville, Pa., Chas. Shults.

National Tube Works, Pittsburg, Pa., George N. Riley, R. N. Speller, L. R. Phillips, W. E. Watson, A. M. Lally.

Garlock Packing Company, Palmyra, N. Y., Edward A. Smith.

Chicago Pneumatic Tool Company, Chicago, Ill., J. W. Duntley, W. O. Duntley, Thomas Aldcorn, C. E. Walker, C. T. Smith, Chas. Booth, G. A. Barden, J. C. Campbell, George H. Hayes.

Independent Pneumatic Tool Company, Chicago, Ill., R. D. Hurley, R. D. Scott, George A. Gallinger.

"Railway Journal," Chicago, E. L. Cook.

Standard Railway Equipment Company, St. Louis, Mo., W. P. Murphy, J. J. Keefe, Peter Flavin.

Thos. H. Dallett Company, Philadelphia, Pa., W. H. Van Sickel.

Ewald Iron Company, Pittsburg, Pa., S. F. Sullivan.

Christopher Murphy & Company, Chicago, Ill., J. Farrell.

THE BOILER MAKER, New York City, George Slate, H. S. Moss.

American Locomotive Equipment Company, Chicago, Ill., C. C. Moore.

Penberthy Injector Company, Detroit, Mich.

Falls Hollow Staybolt Company, Cuyahoga Falls, Ohio, C. M. Walsh.

Crucible Steel Company of America, Pittsburg, Pa., R. D. Kuhn, A. E. Jones.

Railway Materials Company, Chicago, Ill.

Zephon Chemical Company, Chicago, Ill., Mr. Miller.

Manning, Maxwell & Moore, New York City.

Wm. Wood, Media, Pa., W. H. Wood.

Webb C. Ball Watch Company, Cleveland, Ohio.

Otis Steel Company, Cleveland, Ohio, H. B. Hare, A. L. Deverall, George Seavey.

Republic Iron & Steel Company, Chicago, Ill.

Carnegie Steel Company, Pittsburg, Pa.

Cleveland Tool & Supply Company, Cleveland, Ohio.

T. F. Corbett Company, Cleveland, Ohio.

Foot-Burt & Company, Cleveland, Ohio.

"Railway & Engineering Review," Chicago, E. L. Day.

Fuller Bros. Company, New York City, H. H. Linton.

How to Lay Out a Tubular Boiler.

PART VI.

INDIRECT BRACES.

Indirect or diagonal braces of different kinds, either of iron or steel, are being extensively used in tubular boiler construction. The iron braces are usually welded, while the steel braces are without welds. The latter have, from practical and scientific tests, proven themselves from 30 to 50 percent stronger than iron-welded braces, due to the lower tensile strength and uncertainty of the weld in iron braces. Steel braces may thus be made lighter and the factor of safety does not need to be so great as with iron braces. Many authorities are allowing on weldless steel braces 9,000 pounds per square inch sectional area.

Diagonal braces are not allowed the full value of the strength of the brace, due to the fact that they do not strike the head at right angles. Thus, if a brace is allowed 9,000

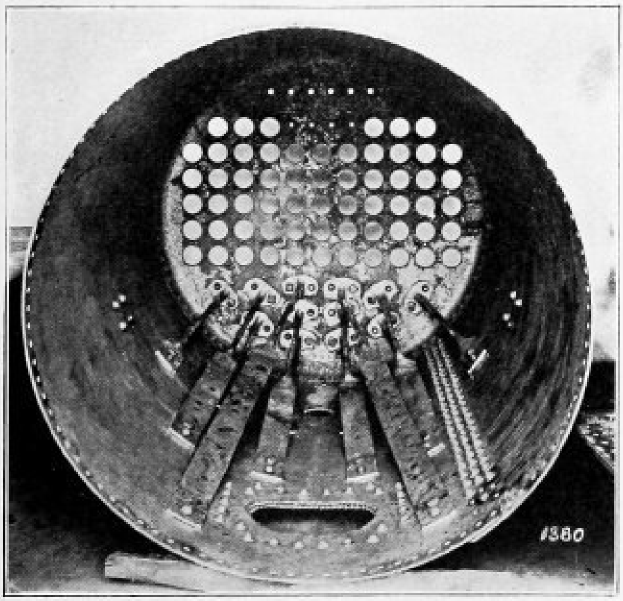


FIG. 29.—BOILER HEAD BRACED WITH DIAGONAL BRACES.

pounds in direct pull, it would be allowed less if set at 10 degrees, and still less if set at 15 degrees.

If A = Area of brace in square inches.
B = Stress per square inch, net section of brace.
C = Length of line at right angles from the surface to be supported to the end of diagonal brace.
D = Length of diagonal brace.
E = Surface to be supported in square inches.

$$\text{Then } \frac{A \times B \times C}{D \times E} = \text{pressure allowed per square inch.}$$

Assuming that the brace is allowed 9,000 pounds per square inch in direct pull, and the length of (C) is 49 inches, with (D) 50 inches and the surface to be supported 49 square inches, the pressure allowed would be found by substituting these values in the above equation.

$$\frac{9000 \times 1 \times 49}{49 \times 50} = 180 \text{ pounds.}$$

The photograph, Fig. 29, and the sectional view, Fig. 30 show the manner of fastening diagonal braces, B and D, Fig. 30, representing the distance C in the formula. From the distances A and C and B and D in Fig. 30, the length of the brace is determined.

In Fig. 31 is shown a layout of diagonal braces for a 60-inch boiler head, in which there are sixty-one 3½-inch tubes. Authorities differ in regard to the area to be supported, but nearly all admit that a certain distance from the flange of the head is self-supporting. It is necessary, then, to determine how far from the flange the head may be considered to be self-supporting. First, however, let us determine the amount that will be supported by the top row of flues.

In Fig. 31 we find that the flues are 7⅝ inches above the center line, and the diameter of the flues is 3½ inches. One-half of 3½ is 1¾, which, added to 7⅝, makes from the center

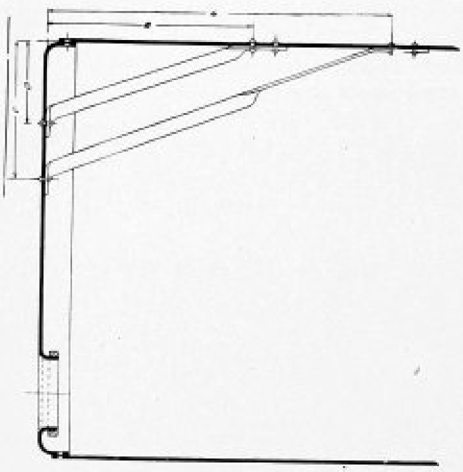


FIG. 30.

line to the top of the flue, 9⅜ inches. The allowance that the flue will support beyond the flue itself is, as explained in previous chapters, a question depending upon the manner and grade of work. It is quite reasonable not to make this allowance too great, as this will cause a much greater stress on the upper row than upon the rest of the flues. Therefore, if we have 1⅛-inch bridge between the flues, we know that each flue is supporting beyond its edge 9-16 inch. From personal observation the writer thinks that the majority are inclined to allow too great a self-supporting distance from the flues.

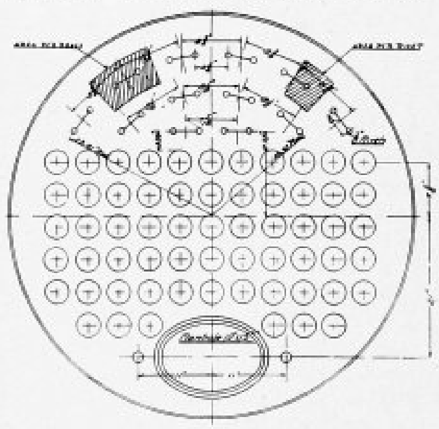


FIG. 31.

One-half the bridge is, no doubt, a very small allowance, yet it is better to cut the allowance rather than have too much.

The following consideration may throw some light on the reason why that part of the head nearest the flange may go unsupported. The sections of plate between the rivet holes in the flange of the head act practically as a series of braces. With eighty rivets in the circumferential seams we would have about 2.35 inches pitch. This, minus the diameter of the rivet hole (15-16 inch), makes 1.41 inches, giving the net section of plate an area of 1.41 × ½ inch = .705 square inches. As this is subjected to a direct pull, allowing 9,000 pounds stress per square inch, we would have for each section 6,345 pounds. Thus, we see that the net section of plate of the head is actually a very strong brace.

Assuming that the mode of fastening the braces to the head entitles us to use the constant 120, we will find that the maximum allowance for ½-inch plate to be

$$\sqrt{\frac{120 \times 64}{175}} = 6.63 \text{ inches, maximum pitch.}$$

The inside diameter of the boiler being 60 inches, the radius will be 30 inches. In order to find the actual distance or height of the segment that we wish to support we will have to make some deductions as follows:

7.625	distance from center line to center of flues.
1.75	distance from center of flue to top of flue.
.56	supported by upper row of flues.
.50	thickness of head.
10.435 inches.	

30 — 10.435 = 19.565 inches. Referring to Fig. 31 we find that we will have three rows of braces. In figuring stays or braces it is assumed that the brace will carry an equal amount on each side. As pointed out, the net section of plate of the head was equal to a brace, so we will assume that the net section of plate will support the head for a distance half way between itself and the next row of braces, but not to exceed the limit as found by the formula. The formula gave 6.63 inches, but to this we add ½ inch, the thickness of the head, and we have 7.13 inches. Thus, we find that from the outside of the head to the nearest row of braces the maximum distance is 7.13 inches.

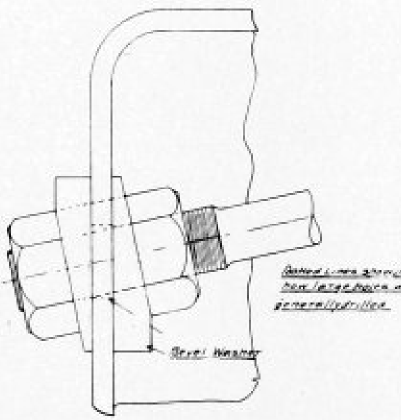


FIG. 32.

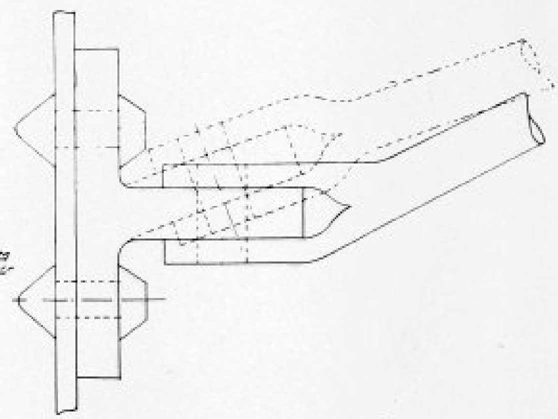


FIG. 33.

We then have 19.565 inches, which is to be divided into three and one-half spaces, giving 5.59 inches as the distance between the rows of braces. This is less than the maximum pitch. Distributing the braces in the three rows with a pitch of 8¾ inches we have each brace supporting an area of 8.75 × 5.6 = 49 square inches. 49 × 175 pounds = 8,575 pounds, stress per square inch of sectional area.

Some authorities will not allow diagonal braces to have less than 1 square inch sectional area. In order to get the full benefit of their strength very short braces should not be used, since the brace should be as nearly square with the head as possible in order to be allowed the full value of its strength. The less value allowed the brace the greater the net sectional area will have to be. In this case if the braces are not too short they will be large enough if they have 1 square inch sectional area.

FACTOR OF SAFETY.

With 60,000 pounds tensile strength and each brace carrying 8,575 pounds, we have 60,000 divided by 8,575 or 7. as the factor of safety, for the braces.

RIVETS IN THE BRACES.

In dealing with the rivets we have to consider them under two conditions as the rivets in the head will be in tension and the rivets in the shell in shear. Since the strength of these is different it will be necessary to figure both. The practice in some places is to figure only the rivets in shear and make the rivets in tension the same size, paying no attention to their greater strength. Assuming the shearing strength as 42,000 and the tensile strength as 50,000 we will readily see that there is a ratio of 25 to 21. Some allow more for the tensile strength of rivets, but as explained in previous chapters the maximum is considered at 55,000 pounds.

Strength of rivets in shear assuming the shearing strength per square inch as 42,000 pounds:

Diameter, Inches.	Area.	Strength, Pounds.
⅞	.601	25,242
15/16	.69	28,980
1	.7854	32,986.6

Strength of rivets in tension, assuming the tensile strength per square inch as 50,000 pounds:

Diameter, Inches.	Area.	Strength, Pounds.
⅞	.601	30,050
15/16	.69	34,500

In Fig. 31 we find that brace rivets are spaced 4¾ inches by 5.6 inches, thus making 4.75 × 5.6 = 26.6 square inches, as the area supported by each rivet 26.6 × 175 = 4,655 pounds, stress per rivet.

With ⅞-inch rivets, tensile strength 30,050, the factor of safety will be 30,050 divided by 4,655 = 6.45. It will be noted that the area alloted to two rivets will exceed the area that the brace will have to carry. In this connection it might be stated that some authorities figure the area from the maximum pitch of rivets or stays, paying no attention to the minimum pitch. Others square both the maximum and minimum pitch, add them togeher and divide the product by two. This, of course, does not give the actual area, but it does serve as a check on unreliable work.

The rivets in the palm of the brace where the brace is attached to the shell will be in single shear. The brace being subjected to 8,575 pounds, the rivets should likewise be figured for this load. Since the factor 7 was used in figuring the brace, it should also be used in figuring the rivets so they will not be weaker than the stay. 8,575 × 7 = 60,025. Our table shows that this would require us to use two 1-inch rivets. Using the factor 6.45 required for the rivets in tension we find 8,575 × 6.45 = 55,315.9. This would require two 15/16-inch rivets.

SIZE OF PALM.

The width of the palm will depend upon its thickness. Assuming that we make the braces out of ⅜-inch steel we will have 1 square inch (the sectional area) divided by .375 = 2.66 inches. To this we must add the diameter of the rivet hole. If made of ½-inch steel we would have 1 square inch divided by .50 = 2 inches, to which we must add the diameter of the rivet hole.

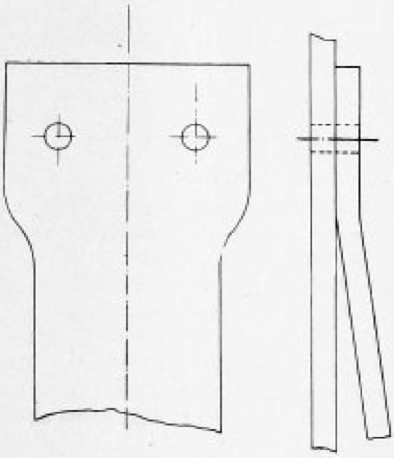


FIG. 34.

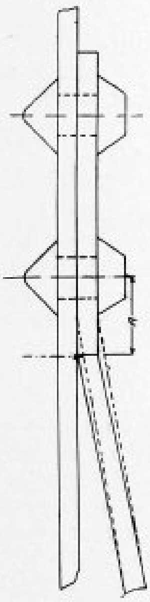


FIG. 35.

FORMS OF DIAGONAL BRACES.

In Fig. 32 is shown a diagonal brace fastened to the head with inside and outside nuts. It will be seen that this brace strikes the sheet at an angle and to have the hole a proper fit it would be necessary to drill the hole small and then enlarge it at the angle at which the brace is set. Practical men know that this is a very costly operation and that it does not pay. The general practice is to drill a hole large enough to permit the brace being set at the necessary angle. This makes the hole too large on the sides, and the part of the hole that is not filled with the brace is packed. Bevel washers are placed on both sides of the head to permit the nuts to be tightened up. This style of brace is generally considered the poorest of bracing.

In Fig. 33 is shown the brace attached to a crowfoot. The crowfoot should be set as indicated by the dotted lines as this gives the brace a proper pull, and not as shown by the solid lines where there is an eccentric loading.

In the use of steel braces the length of the distance *A*, Fig. 35, should not be too great as the braces will have a tendency to straighten out, as shown by the dotted lines. In Fig. 34 we have the palm wider where the rivet holes are placed. There are many who think that the first rivet in Fig. 35 carries more than its share. It is very reasonable to consider that the first rivet is subjected to a prying-off strain, and many contend that both rivets should be subjected to the same conditions. In the case of Fig. 35 we will consider that the rivet is subjected to a prying-off strain. Rivets are either subjected to shear or tension and if the prying-off strain is tension, we find that the strength is increased, because the tensile strength

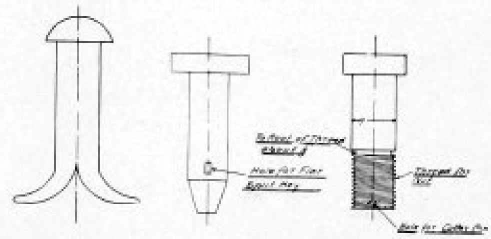


FIG. 37.

is greater than the shearing strength. Many claim that the palm of the brace should be as shown in Fig. 34, but the general satisfaction given by the brace shown in Fig. 35 indicates that the prying-off strain on the first rivet is not of great consideration. The one main feature is not to have the distance *A*, Fig. 35, too great.

Fig. 36 is a view of an eye-brace as used between two angles. To figure out the proper area for both the round and square parts of the brace we must consider the area of the body of the brace. Thus if the body of the brace were 2 inches in diameter, the area would be 3.1416 square inches. To find the size of (*A*) take the square root of 3.1416, which gives 1.79 inches for (*A*). Having found the proportions of *A* and *B*, and assuming that the material of the angles is of the same quality as that of the brace, we must find the values of *F* and *E*. Assuming that *E* is ¾ inch, in order to make (*F*) strong enough, we must multiply *E* by 2 and divide 3.1416 by that product. $2 \times \frac{3}{4} = 1\frac{1}{2}$ inches. 3.1416 divided by 1.5 = 2.094 inches, value of *F*. *C* should be a fraction greater than *B* to permit the brace to go in and have a little clearance. The proportions of Fig. 36 are figured out for no particular stress per square inch, but merely to show the manner of finding the proper proportions.

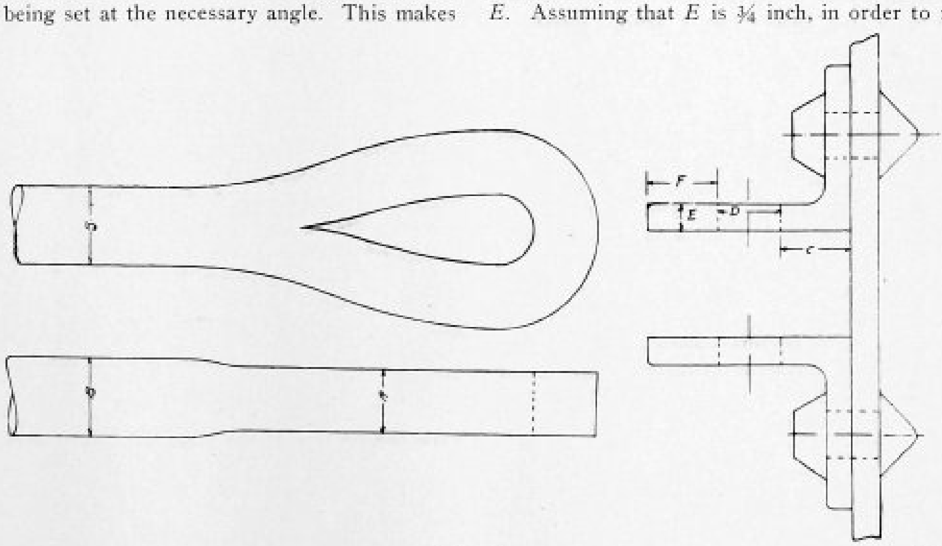


FIG. 36.

BRACE PINS.

There are several different kinds of brace pins. Three, which are in common use, are shown in Fig. 37. The pin shown at *A* is a rough, round bolt, split and bent over. It is a very cheap pin, but hard to put in as well as to remove. At *B* is shown a pin something on the order of the pin *A*, but it has a separate split key. This is not a very satisfactory pin. *C* is a turned pin with nut and cotter key. There is also a recess on the pin so that the threads will not come upon the body of the pin. It is customary in some shops to have the diameter of the threaded part smaller than the body *A*. This pin has much to commend its usage. Many concerns, however, apply simply the rough machine bolt.

STRENGTH OF BRACE PINS.

The strength of brace pins is an unsettled matter. It is assumed that the pin can be treated in the same manner as rivets, that is, they can be so placed as to be in single shear or in double shear. Some authorities do not allow any value for the pin in double shear and require the area of the pin to be equal to the area of the brace.

The British Columbia rules allow the area of the pin to be 25 percent less than the area of the brace, but at the same time they allow different values on braces. Thus, if a brace made of iron were allowed 6,000 pounds per square inch, it would be satisfactory for the pin to be 25 percent less in area. Should the same style and size of brace be made of steel and not worked in the fire, the brace would be allowed 9,000 pounds per square inch of area. It will be seen that the mere fact that the body of the brace is made of two different metals and by two different methods will give different stresses. Thus they require the same size pin for a stress of 6,000 pounds as they do for 9,000 pounds. This does not seem very consistent.

When the brace pin is in double shear it may be considered as a rivet. Assuming that the shearing strength of the pin is 42,000 pounds per square inch in single shear, the strength in double shear is generally considered as 85 percent more than this, or $42{,}000 \times 1.85 = 77{,}700$ pounds.

What size pin would be needed for a 2-inch diameter brace, allowing 60,000 pounds tensile per square inch for the brace? 2 inches, diameter = 3.1416 square inches, area. $3.1416 \times 60{,}000 = 188{,}496$ pounds, stress. 188,496 divided by 77,700 = 2.43 inches, diameter of pin. It will be seen that in this case the diameter of the pin is larger than the diameter of the brace. If the tensile strength of the brace is less than 60,000, the diameter of the brace pin would, of course, be less.

Taking the same proportions as to strength, let us figure out the pin with a smaller brace, say, 1½ inches diameter.

1½ inches, diameter = 1.767 area. $1.767 \times 60{,}000 = 106{,}029$ pounds.

106,029 divided by 77,700 = 1.365 inches, diameter of pin. It will be seen that with 2 inches diameter of brace, 60,000 pounds tensile strength, 77,700 pounds shearing strength, the diameter of the pin is larger than the diameter of the brace. In the other example, with 1½ inches diameter of brace, but with the same tensile and shearing strength, the diameter of the pin is less than the diameter of the brace.

Braces are allowed different stresses according to the mode of work. Welded braces are not allowed as great a stress per square inch as braces that are weldless. Assuming the tensile strength as 54,000 and allowing 9,000 pounds stress per inch with a weldless brace, the factor of safety is 6, but with a welded brace, allowing only 6,000 pounds stress per inch, the factor is 9. The increased factor is on account of the weld. It will be readily seen that the pin does not lose, whether the brace is welded or not. Therefore, the pin should have a factor of safety regardless of the factor of safety of the brace or material in the brace. A factor of 6 should be ample for brace pins.

With a factor of 6, and allowing 9,000 pounds stress per square inch, what size pin will be needed for a brace 1½ inches diameter, 60,000 pounds tensile strength?

$$1.5 \times 1.5 \times .7854 \times 9{,}000 \div \frac{42{,}000 \times 1.85}{6} = 1.23 \text{ square}$$

inches, area of pin.

$$2\sqrt{\frac{1.23}{3.1416}} = 1.25 \text{ inches, diameter of pin.}$$

While 6 was used as the factor of safety of the pin, it will be seen that the factor for the brace is $60{,}000 \div 9{,}000 = 6.666$.

How to Heat and Drive Steel Rivets.*

BY JAMES CROMBIE.

In riveting, no matter whether by hand or machine, there are several matters that must first receive attention before any rivets can be driven or a satisfactory job made.

We have first the assembling of the work. The plates must be bolted together and all the rivet holes reamed out to correct size, *i. e.*, 1/16 inch larger than the size of rivet to be used. Reamers are made with about 3 inches of tapered end and 4 inches of straight section for each different size of hole. This insures that the hole will be parallel, or the same size all the way through. After reaming, the work should be taken apart and all burrs and pieces of cuttings left between the plates by the reamer scraped off and the two surfaces made perfectly clean. The outer sides of holes should also be gone over with a broad countersink drill to remove the burrs from the edge of the hole. The work should then be bolted up close and any joints warmed and closed up with hammers or squeezed in the hydraulic machine.

RIVETS.

Rivets should be of best quality of open-hearth steel, extra soft grade, ultimate strength 45,000 to 55,000 pounds, elastic limit not less than one-half of the ultimate strength,

$$\text{elongation} = \frac{1{,}400{,}000}{\text{ultimate strength}}$$

maximum phosphorus .06 percent, maximum sulphur .04 percent, cold and quench bends 180 degrees flat on itself without fracture on outside of bent portion. On being nicked and broken off the steel should be of a light gray color, showing a close-grained silky fracture. A coarse-grained, dark-colored rivet steel should be looked on with suspicion, as the chances are that after being riveted up the rivet head will drop off. Excess of sulphur or excess of phosphorus will make the steel "short" or brittle, causing the rivets to break. We had a lot of trouble with one consignment of rivets, for after being driven the heads or points of a large percentage of these rivets would drop off, not immediately after being driven, nor when the plate edge was being calked, but 4, 5 or 10 hours after they were finished. Some of these broken rivets, 4 inches long, were backed out of the hole, they were bent 180 degrees on themselves cold without any sign of fracture. The trouble was apparently excess of phosphorus, causing segregations in spots in the steel. Where these spots were the rivet would break off easily and the material was very brittle. These rivets went into the scrap heap in double-quick time.

HEATING THE RIVETS.

Heating the rivets does not depend so much upon the kind of fire or fuel as upon the rivet heater. Given a good, willing heater, and no matter how adverse the conditions are, he is always there with a good hot rivet and the work goes swinging

* Awarded first prize in the Champion contest.

along. Good work can be obtained from a coal or coke fire, either with a side or bottom blast. There is always the danger in these fires of overheating the rivets or they may be left in the fire too long while the squad is changing or during the meal hour. The rivets will then have a heavy scale on them and be wasted, becoming too small to fill the hole properly; this should be avoided.

Rivets that are sparking hot or show signs of overheating should be discarded. If such rivets should be driven through any mistake or any heads show signs of being burnt on examination after the job is finished, the question arises, whether more injury will be caused to the plates by cutting those rivets out or whether it will be best to leave them in. I believe in having them out if at all possible, either by cutting off the heads and backing them out with a punch and hammer or drilling them out. There should be no danger of burnt rivets, although if too many rivets are put into the furnace at one time and the work is lagging behind, the rivets will quickly get scaled and waste.

I have got good results from an oil furnace without any baffle brick, using pitch oil and allowing the flame to blow right on to the rivets. This was principally on large sized rivets. I believe that the best results are obtained from a good oil furnace with a baffle-brick or fire wall using compressed air. We use oil rivet forges burning fuel oil, or gas oil with compressed air, and get nice, soft rivets, just a bright cherry red or white-hot if desired. This style of forge leaves nothing to be desired. It has a fire-wall, heats rivets quickly and does not cost much to run. The oil and air is mixed before entering the furnace, and then passes through a small opening at the side of the furnace. Combustion then takes place, the flame striking the baffle-brick or fire-wall, then passing over the top of the fire-wall and heating the chamber where the rivets are. The heat then radiates from the top down upon the rivets.

Rivets that are to be driven by hand or by an air hammer require more heat than rivets for the hydraulic riveter. A cherry red will be best for a hydraulic machine, but for an air hammer or hand riveting the rivets should be a light yellow, turning to white, but not sparking. That would be about 1,500 degrees F. for hydraulic and 2,000 degrees for hand-driven rivets.

MACHINE RIVETING.

There are several kinds of machines for riveting. I have seen good riveting done on an old steam riveter, each rivet receiving from two to three blows. This style of machine has gone out of date and is seldom seen now.

We have our good friend the hydraulic riveter or "Bull." This machine may be considered ideal both as to operation and effect. The water is supplied in pipes at a pressure of 1,500 pounds or more per square inch. In the best class of machines the pressure is delivered through different valves, so that the operator has control of the pressure at all times, reducing or increasing the pressure according to the size of rivet. The best pressure is 100 tons per square inch of rivet section. The water, after the rivet is squeezed, passes back to the tank again, and is used over again, so that there is very little waste of water. The full pressure is available throughout the full length of the stroke, so that the rivet is properly upset, thoroughly filling the hole from end to end, and also squeezing the plates close, holding them for several seconds while the rivet is contracting or cooling off.

For heavy work, the machine should have a plate-closing device, so that the plates can be held close together before any pressure is applied to the rivet, the rivet dies being controlled by separate levers and working in the center of the plate-closing device yet separate from it.

A good hydraulic crane is best suited for handling the work at the riveter. It is quick in action and very sensitive, and the hole is quickly centered with the rivet dies. All levers should be handy for the operator, the same operator controlling the levers for both crane and riveter. The work should be hung fair. A little time spent on this will be gained later on and temper saved, too.

After the work has been cleaned and bolted up it is squeezed up and all the bolts tightened. The boiler should then be tacked at each quarter, then at each eighth and afterwards at every third or fourth hole. The remaining rivets are then driven, going right along around the boiler, allowing the full pressure of the machine to remain for a few seconds on each rivet as it is driven. At the longitudinal seam or butt-joint the end should be tacked first, to prevent springing, then at the center, after which the rivets may be driven in succession. The operator should be given to understand that it is not the number of holes he can fill up but the quality of the work on the testing floor that counts. The danger to be looked for is the crushing or scalloping of the plate in front of the rivet, through excessive pressure or through too much being planed off the plate edge. Also the joint may fail by not being properly proportioned, by the plate breaking along the line of rivets, by the shearing out of the rivets or by the shearing of the plate in front of the rivets, and if the work is not hanging fair the rivets may be driven offside, thus necessitating cutting out.

All rivets should be put into the holes from the outside, as it is much quicker and requires a man less on the job. A man inside the boiler is apt to get hurt, too.

There is also the pneumatic lever type of machine, the hydro-pneumatic type; the pneumatic toggle-joint machine giving a full pressure only at end of stroke, and the portable hydraulic type similar to the "Bull." The latter is handy for riveting around the ends of boilers or furnace mouths, or around the flanges of flues in Lancashire or Cornish boilers. The water, after it is discharged from this machine, does not return to the tank as in the fixed riveter, but is conducted through a rubber hose to the nearest sewer. This type is wasteful as regards water.

I pin my faith on the hydraulic riveters, as first-class work can be obtained from them. The rivets do not require such an intense heat, therefore there is no risk of burnt rivets, and there need be no guess work about the pressure applied to each rivet.

I use high-speed air hardening steel for rivet dies on the "Bull." The initial cost is high but they are all right. I have driven 180,000 rivets with four pairs of dies made from this steel, and they have not been to the tool room since we started to use them. They are still sharp on the edge and are only beginning to show slight signs of wear. The most that can be got from a pair of ordinary cast steel rivet dies is about 4,000 rivets, while these, I believe, will average 50,000 each.

Another good riveter is the air hammer or "Gun," working with compressed air at a pressure of 80 to 100 pounds per square inch. With this machine a careless riveter, or one wanting to make a show, may drive a short rivet, too short to properly fill the hole, merely blinding the work by allowing his hammer handle to describe a large circle, thereby spreading the rivet instead of allowing it to upset into the hole. If there is enough stock in the rivet and the rivet is driven fair into the hole, these hammers will give a good tight rivet that will not require calking. With the air hammer it is necessary to hammer up the plate in front of the riveter and to have the work all thoroughly closed up, as there is no squeeze as in the hydraulic machine. It is not necessary to tack the plates as in bull riveting, but go right along working towards the joint and bringing any slack to the joint. I have used these hammers extensively, and with ordinary care in working a good tight job can be made. I have been using high-speed steel for rivet snaps for these hammers, and believe that they are better than cast steel, but would not care to say anything definite about them yet.

HAND RIVETING.

In work to be riveted by hand it is better to have all holes countersunk. The countersink must be narrow and deep, from 1/16 to ⅛ inch of the bottom of the hole in the first plate, then if corrosion or wasting occurs the rivet and plate will both wear equally and the strength of the rivet will not be impaired. Where a shallow, broad countersink is used there is more chance of the rivet breaking off than where a narrow, deep one is used. The rivets may be snapped by hand, but this practice has gone out, as the rivets are not so reliable as when countersunk.

The best practice is to finish on the third rivet, that is, we have our squad all ready to start with hammers, the hole is hammered close and the first rivet is put in and hammered down but not finished, the second hole is plied close, the rivet hammered down as before, the same with the third and fourth. The fifth rivet is then put in, the sixth hole plied close and our squad goes back to the third rivet, giving it a few heavy blows, then finishing it off with their riveting hammers. Thus they work right along, always finishing on the third rivet back. Working this way every rivet is tight and the whole seam is perfectly hard. In fact, a calking tool will not make much impression on the plate edge, as it will be solid, and will not have soft spots, which mean leaks. On light plates our squad may finish up on the second rivet back. This will also give tight work. In tank work the rivets may be put right in and finished up, but in boiler work, where heavy pressures are to be carried, I believe in working back to the third rivet all round the seam.

THE HOLDER-ON.

It is hard to give any hard and fast rule regarding holding up the rivets, as there are so many different classes of boiler work and so many different tools to be used around a boiler in holding up. We have our dolly bars and water-space hammers, and also long-handled hammers, supported on a hook. Where possible it is best to use the compressed air holder-on. In all these things we must be guided by circumstances, always endeavoring to get the head well up or the rivet will not be tight.

Triangulation.

THE LAYOUT OF A "Y" CONNECTION.

The plan and elevation of a "Y" connection, such as it is frequently necessary to construct for the uptakes of boilers or in branch pipe work, is shown in Fig. 10. The main pipe is circular and the two branch pipes are oval in shape, the diameter of the large pipe and major diameter of the small pipes being the same. It will be seen that not only would the connection from the large pipe to one of the smaller ones be an irregular and difficult piece to lay out, but that the interesection of two of these irregular pieces make the problem still more complicated. The fact that the connections to each of the branch pipes are exactly similar brings their intersection in a vertical plane, as shown by the line *A*4. Divide the half plans of the large pipe and one of the small pipes into the same number of equal spaces. Number the points on the large pipe 1, 2, 3, 4, 5, 6 and 7, and on the small pipe 8, 9, 10, 11, 12, 13 and 14. Now divide the surface of the connection into triangles by connecting points 1-8, 2-9, 3-10, etc., by solid lines and the points 2-8, 3-9, 4-10, etc., by dotted lines, as shown in Fig. 10. It is necessary to find the true length of each of these lines of which we have just drawn the plan and elevation, in order to obtain the shape of the connection when stretched out flat.

Draw the line *BA*, Fig. 11, and at any point, as *Y*, square up the line *XY*. It will be seen from the elevation, Fig. 10, that the vertical distance between the upper and lower ends of each of the lines of which we wish to get the true length is the same; that is, it is the perpendicular distance between the lines 1-7 and 8-14. Therefore, lay off this distance in Fig. 11 from *Y* to *X* and then set the trams to the distance 1-8 in the plan, Fig. 10, with *Y* as a center, Fig. 11, lay off the distance *Y*8

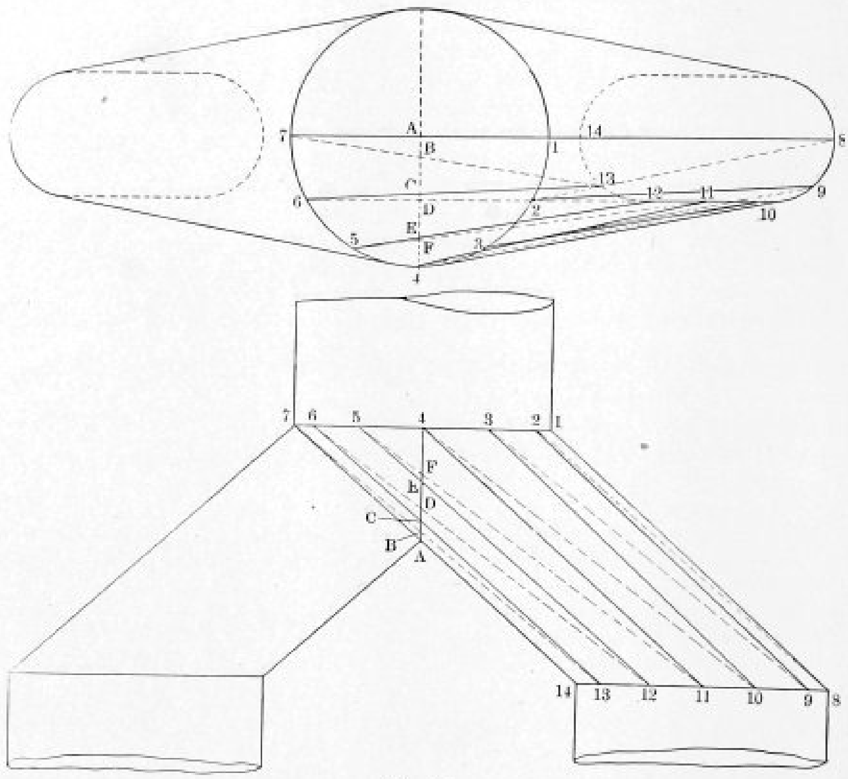


FIG. 10.

to the right of the line *YX*. Again, set the trams to the distance 2-8 in the plan, Fig. 10, and with *Y* as a center lay off the distance *Y*8, Fig. 11, to the left of the line *XY*. Draw the solid line *X*8, and also the dotted line, *X*8. These lines will then be the true lengths of the solid line 1-8 and the dotted line 2-8, shown in Fig. 10.

Perform the same operation for each of the solid and dotted lines in Fig. 10, obtaining the lines *X*9, *X*10, *X*12, *X*13 and *X*14, Fig. 11. In order to avoid confusing the figure, since all of the lines are of nearly the same length, draw the solid lines at the right of the figure, and the dotted lines at the left.

Having obtained the pattern for the entire connection from the large pipe to one of the small ones, it is now an easy matter to locate the line of intersection between the two intersecting connections. Set the trams to the distance 7*B* in the plan, Fig. 10 and with *Y*, Fig. 11, as a center lay off the distance *YB*. At the point *B* square up the line *B B'* until it intersects the line *X*13; then set the trams to the distance *X B'* and with the point 7, Fig. 12, as a center, lay off the distance 7*B* along the line 7-13. Again set the trams to the distance 6*C* on the plan, Fig. 10, and with *Y*, Fig. 11, as a center lay off the distance *Y C*; at *C* square up the line *C C'* until it intersects the line *X*13

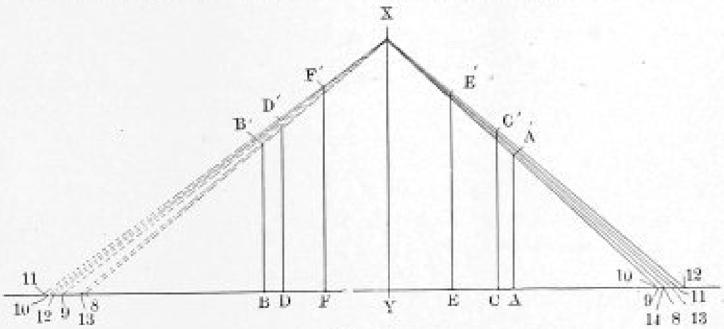


FIG. 11.

Having obtained the true length of all the lines which form the triangles into which the connection is divided, we are now ready to lay out the sheet as it will be before it is rolled up. Draw the line 7-14, Fig. 12, equal in length to the line 7-14, shown in the elevation, Fig. 10. Now set the trams to the dotted line *X*-13, Fig. 11, and with 7, Fig. 12, as a center draw

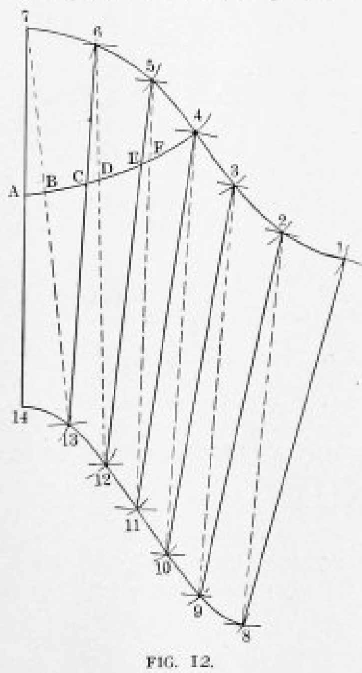


FIG. 12.

an arc at the point 13. With 14 as a center and the dividers set to the distance 14-13 (the length of one of the equal spaces on the half plan of the branch pipe), strike an arc intersecting the arc previously drawn at point 13. Again set the trams to the solid line **X**-13, Fig. 11, and with 13, Fig. 12, as a center, strike an arc at point 6. With 7 as a center and with dividers set to the distance 7-6, Fig. 10 (the length of the equal spaces in the half plan of the large pipe), strike an arc intersecting the arc previously drawn at point 6. Proceed in a similar manner, locating the points 5, 4, 3, 2 and 1 on the long edge of the sheet, and the points 12, 11, 10, 9 and 8 on the short edge of the sheet.

at the point *C'*; then set the trams to the distance *X C'*; and with point 6, Fig. 12, as a center lay off the distance 6*C* along the line 6-13. In a similar manner locate the point *D* on the line 6-12; *E* on the line 5-12, and *F* on the line 5-11. Draw a smooth curve through these points, and then the figure *A*, 4, 1, 8, 14 represents a half pattern of the connecting pipe.

This problem shows how the principles of triangulation make possible the solution of problems which require the development of surfaces of which there is no regular form or taper. The only inaccuracies or errors which creep into this, as well as any other problem which is solved by triangulation, are those due to the fact that the lines forming the triangles into which the surfaces are divided are considered as straight lines when, as a matter of fact, they are slightly curved. Unless there is a very great curvature to the surface, however, this error is very small and the patterns developed by this method will be found to fit nicely into the required positions.

A Hurry-Up Job.

BY JOHN COOK.

Having read in THE BOILER MAKER an account of a stack which was erected by six men in six and a half hours, I wish to give the following account of a job which compares very favorably with this in point of speed.

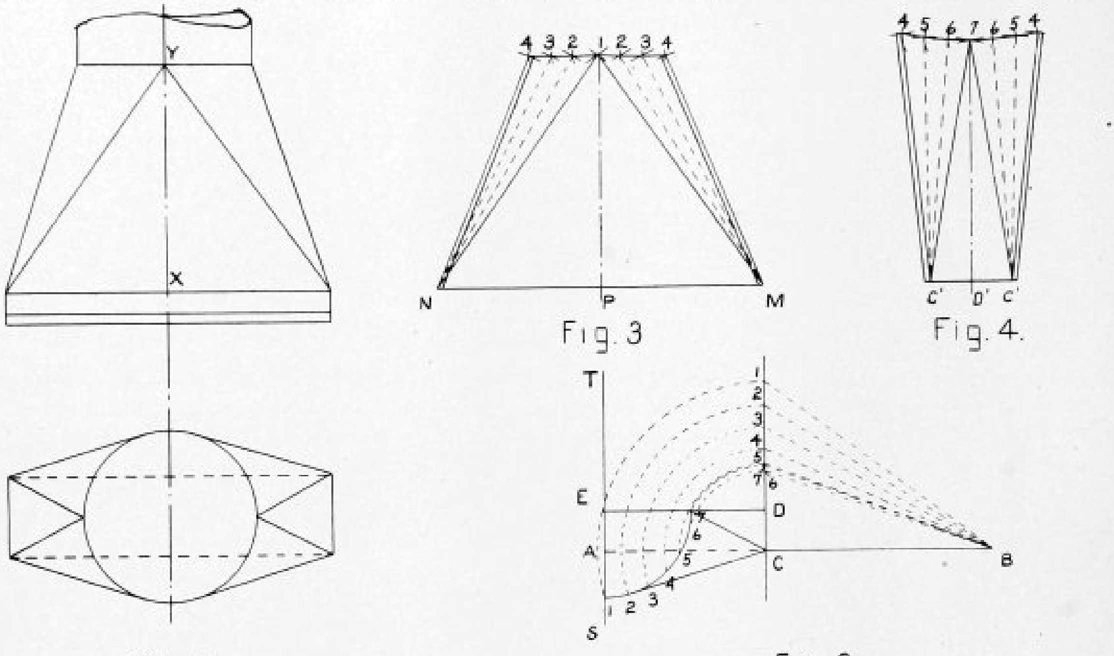
Coming into the shop on Tuesday morning I found a rush order for two stacks, 36 inches in diameter by 70 feet high, with rectangular bases. The stacks were to be made half of No. 10 and half of No. 12 gage iron with bands at the top and bottom. It was 9 o'clock before we could start punching. At that time two punches were started and two gangs were set to work marking off for them, each gang being composed of one man and one boy, or eight altogether. Both the men and boys were apprentices. At 11 o'clock enough material was punched to begin rolling, and at 3 o'clock in the afternoon all the sheets were punched and rolled. At 5 o'clock (quitting time) there were two sections of eight courses each of the No. 10 and three courses of the No. 12 riveted together. At noon the next day the stacks were ready to ship.

There were seventeen round courses, and each of these sheets had 102 holes to be punched. The bottom courses were round at the top and rectangular at the bottom, with 6-inch strips all around. As they were made in four pieces, there were 20 holes to punch in each of these. The total time taken for this job was twelve working hours for eight men, or ninety-six hours for one man.

LAYOUT OF THE BOTTOM COURSES OF THE STACKS.

The accompanying sketch shows the method used in getting out the bottom courses of the stacks whose rapid construction is described above. It will be seen from the plan and elevation, Fig. 1, that this course is round at the top and rectangular at the bottom. First draw the line *ST*, Fig 2., and at any convenient point, as *E*, draw the line ED at right angles to it. With *E* as the center, and a radius equal to the radius of the stack, draw the quarter circle and divide it into as many equal spaces as there are in the quarter circumference of the stack, marking each point as shown by the figures 1, 2, 3, 4, etc. Lay until point 4 is reached; then the lines *N*4 and *M*4 would locate the rivet lines for the sides of this sheet. As the plate is bent, however, on the lines 1*N* and 1*M*, it will be seen that this would bring a rivet hole on the sharp corner; to avoid this, draw the rivet lines as shown about ¾ inch in toward the center line but parallel respectively to the lines 4*N* and 4*M*.

For the side patterns, shown in Fig. 4, set the trams to the distance *DC*, Fig. 2, and with *D'*, Fig. 4, as a center locate the points *C' C'*. Center punch these points and with the trams set to the distance *B* 7, Fig. 2, and the points *C' C'*, Fig. 4, as centers, strike arcs intersecting at 7. Then reset the trams to the distance *B*6, Fig. 2, and with the points *C' C'*, Fig. 4, as centers strike the arcs 6, 6. Also with the dividers set to the space 6-7 on the quarter circle, Fig. 2, and with point 7, Fig. 4,



PATTERNS FOR BOTTOM COURSE OF STACK.

off from the points *E* and *D* half the width of the base of the stack, locating the line *AC*. Make *ED* and *AC* equal in length to half the length of the base: thus making the figure *EDC*1 a quarter plan. With a straight edge laying on the points *C* and *D*, draw the line *CD*, extending it indefinitely, as shown, then with the trams set from the point *C* to the points 1, 2, 3, 4, etc., on the quarter circle describes the arcs shown dotted until they interesect the line *CD* at points 1, 2, 3, 4, etc. Extend the line *AC* to *B*, making *CB* equal to *XY*, Fig. 1, the height of the course. Connect the point *B* with the points 1, 2, 3, 4, 5, 6 and 7; then the lines *B*1, *B*2, *B*3, etc., will be the true lengths of the lines drawn from *C* to the points 1, 2, 3, 4, etc., in the plan view.

As the course is to be made in four sections, lay out first the front or back section, shown in Fig. 3. Draw a line on the sheet at a distance from the edge equal to the distance at which the rivet holes are to be located from the edge of the plate; then set the trams to the distance *AC*, Fig. 2, and with *P* as a center locate the joints *M* and *N*. Center punch these points and set the trams to the line *B*1, Fig. 2, and with the points *M* and *N*, Fig. 3, as centers, strike the arcs intersecting at 1. The center line may then be drawn from 1 to *P*. Again, set the trams to the line *B*2, Fig. 2, and with *M* and *N*, as centers, strike the arcs 2, 2. With the dividers set to the distance 1-2 on the quarter circle, Fig. 2, and with 1 (Fig. 3) as a center strike the arcs 2, 2 intersecting those which were made from the points *M* and D. Do the same with the rest of the points as a center, strike the arcs 6, 6 intersecting the arcs previously drawn. In a similar way locate the points 5 and 4, Fig. 4; then the lines *C'*4 would be the rivet lines for these two sets of patterns. Since, however, the rivet holes in Fig. 3 were located ¾ inch in towards the center from the lines *M*4 and *N*4, in order to match the rivet lines in the side patterns, Fig. 4, should be located ¾ inch outside the lines *C'*4, as shown by the solid lines parallel to the lines 4*C'*.

It seems to the writer that the diagram, Fig. 2, for developing the parts of the patterns which must be laid out by triangulation saves considerable time, as the whole thing is laid down together and cannot easily be lost sight of.

How to Heat and Drive Steel Rivets.*

BY J. T. GOODWIN.

DRIVING RIVETS ON A "BULL" MACHINE.

The question of driving an absolutely tight rivet of steel or iron depends entirely on the manner of preparation and the necessary tools for doing the work. Of late years steel rivets have grown in prominence and it is recognized almost universally that there is nothing better when properly handled for giving a good serviceable job. One of the most important factors to make a rivet tight without calking is the fitting of plates and condition of holes before applying the rivets. The

* Awarded second prize in the Champion contest.

plates should be iron to iron and the holes reamed fair, the burrs removed to insure a sufficient and perfect upsetting of the shank as well as the formation of the head. The riveting machine must be in perfect order as far as alinement of dies is concerned and with sufficient tonnage as required for proper operation. There is no question as to having the most perfect rivet that can be driven at this modern day in this manner.

Friction plays an important part in strengthening riveted joints, and is more effective when pressure is retained until the rivet cools off. Experiments by Considere show that at a riveting temperature of 600 to 700 degrees C. the friction reaches a maximum, being then greater than when the rivet is rose-red, say, 1,000 degrees. Prof. Bach concludes it is not the temperature of the rivet at insertion which is important, but at the moment of finishing the point. In machine riveting his experiments show that within limits the friction increases with the duration of the pressure on the rivet, which we must admit is logical, and unquestionably has proven eminently satisfactory to those of large experience in the line of "Bull" machine riveting.

Fifty to one hundred and twenty-five tons pressure should be used, varying as the size of the rivets varies from ¾ to 1¼ inches diameter, and you are urged to take into consideration the thickness of plates to prevent deformation of metal.

Button-head formation I consider most desirable on machine riveting, believing that the upsetting action which is necessary to bring such a head into spherical form improves the strength of the rivet.

In reference to the soaking of rivets I would consider it a bad practice as well as an expensive one. They should be heated slowly and uniformly, but not lay unnecessarily in the fire.

We may consider the riveting temperature as from 1,800 to 2,000 degrees F. for steel rivets. That would be all that is necessary with a sufficient duration of pressure retained, say, 4 to 5 seconds with automatic cooling device for your dies. Authorities state that in heating a steel rivet we decarbonize it after it reaches 2,400 to 2,500 degrees F., and where fuels are used that tend to reduce the carbon, it depreciates the rivet to that extent.

The question of forges depends entirely on the fuel being used. In addition to coke and oil (which is good) for this heating I herewith submit a table of analysis of fuel gases which demonstrates the different mixtures that may be of some assistance in showing the essential properties to retain the carbon in the rivet.

ANALYSIS OF FUEL GASES.

	Natural Gas.	Coal Gas.	Water Gas.	Producer Gases. Anthracite.	Producer Gases. Bituminous.
CO—Carbon monoxide..	.50	6.00	45.00	27.00	27.00
CO_2—Carbon dioxide....	.26	.50	4.00	2.50	2.50
H—Hydrogen.........	2.18	46.00	45.00	12.00	12.00
CH_4—Marsh gas........	92.60	40.00	2.00	1.20	2.50
C_2H—Olefiant gas.......	.31	4.00	.....	.....	.04
N—Nitrogen..........	3.61	1.50	2.00	57.00	56.02
O—Oxygen	.34	0.50	0.50	0.30	0.30
H_2O—Water............	.....	1.50	1.50	.....	.....
H_2S—Hydrogen sulphide.	.18	.....	.....	.....	.....

Reasoning from the analysis of the gases shown above it would seem possible that prolonged heating in natural gas might, by the absorption of the sulphur from the hydrogen sulphide, injure the rivet; further, it would seem that of all fuels water-gas is best adapted for rivet heating. It will be noted that water-gas has a larger percentage (45) of carbon monoxide, and this gas, owing to its carbon content, should tend to prevent burning out of the carbon in the rivet. This whole matter, however, properly belongs to the chemist, since by his methods alone can these effects be definitely ascertained.

PNEUMATIC RIVETING.

It goes without saying that to drive a satisfactory rivet to be tight without calking, much care must be exercised in the preparation of the sheets. More especially should precaution be used with pneumatic than with bull machines, as you do not have the pressure at your command to assist you in closing up the plates. Your sheets should be well up, sufficiently so to prevent any washers forming between the sheets from reaming the hole. When the hole is reamed clear, the burrs removed and the holding-on equal to the emergency, no trouble should be experienced with an intelligent operator and sufficient quantity of air. In other words, with the required facilities, *i. e.*, air pressure, pneumatic holder-on and long stroke hammer with an intelligent operator, a steel rivet can be made tight without calking.

It is a well-known fact that excessive air pressure in work of this kind is not in the least objectionable, as complaints of not having sufficient air to do the work properly are frequent in even well regulated shops. The pressure necessary under ordinary circumstances is from 90 to 120 pounds per square inch.

For holding-on, an air device is the most acceptable, and is unquestionably indispensable in certain places. A cone-cup holder-on bar is very good when the first named cannot be used conveniently, and then the Pryor holder-on bar is very safe as a lever holder-on, and is very convenient in cylindrical forms. I consider the most important fact in making a tight rivet is the manner of holding-on. If that is done properly the long-stroke hammer will make the job first class, provided you have an intelligent operator, by starting off slowly, to permit the shank to swell and also to prevent the backing of the head.

The next point to consider is the treatment of the steel rivet in heating. My first preference in fuel is artificial (water) gas, next to that, screen coke twice the size of pea coal, which keeps a nice clean rivet, and has the tendency to work with a temperature not exceeding 2,300 degrees F. uniformly heated, with increase of temperature at the end. A rivet at the fusion point should not be used to be perfect. Forges should be adapted according to fuel used.

HAND OR SNAP RIVETING.

Hand, or so-called snap riveting, has been popular since the early history of boiler making, being succeeded in a large measure of late years by more improved and modern tools, such as machine riveters and long-stroke pneumatic hammers. These inventions serve as a necessity when one considers the increased thickness of metals that are required to meet the demand of steam pressures which are used in modern steam boilers. Much can be said of this style of driving rivets, and like all other forms for tight work it is absolutely necessary that the strictest care should be taken to make the completed work as perfect as possible, and in doing this it is very essential that the plates should be together, free from slack, thoroughly bolted, with holes reamed fair and burrs removed before installation of rivets.

The temperature of rivets should be as near as possible to 2,300 degrees F. The rivets should be plugged squarely in the hole by two strikers, using, say, 8-pound mauls (I say with two maulers, as I consider it the cheapest way to snap a rivet), and a half-steeple button set for the formation of the point. This set is a slight variation from a button head.

The holding-on should be, if possible, with a pneumatic device; if not, with a lever or sledge bar with a conical cup to prevent the flattening of the head and destroying its conical shape.

As to fuel, artificial gas or screen coke is the most desirable.

In writing up these different subjects of the driving of rivets the writer would say it is needless to mention unnecessary drifting of holes, as it is injurious and should not be practiced.

WELL ADAPTED FORGES.

A very good closed forge for using artificial gas for rivet heating has the following dimensions: Combustion chamber to be 12 inches by 12 inches by 5 inches deep, arched on top, lined throughout with fire-brick, connection through at top in center of chamber with small vent hole on each side, 3 inches from the end, with a 5-inch by 3-inch slide door for depositing and removing rivets. The gas and air is mixed before it reaches the chamber by a Y connection, where the supply of each can be regulated. The mixture then enters the chamber through a 1-inch pipe. This forge will give good results in cost, etc.

I would recommend a 12-inch by 20-inch by 12-inch deep open-top forge with hood to cover, an adjustable grate, removable ash pan for cleaning, etc., with no less than 5-ounce fan blast, as a good type of forge for burning coke.

Rules and Regulations Prescribed by the British Board of Trade for the Inspection and Construction of Steam Boilers.

(Continued from May issue.)

Iron plates and iron rivets:

$$\frac{100 \times d^2 \times .7854 \times n \times C}{p \times T} = R.$$

Steel plates and steel rivets:

$$\frac{100 \times 23 \times d^2 \times .7854 \times n \times C \times F}{4.5 \times S_1 \times p \times T} = R.$$

Fig. 1.

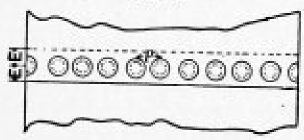


Fig. 5.

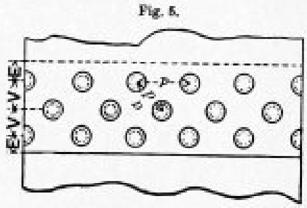


Fig. 2.

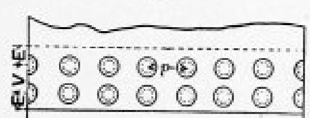


Fig. 6.

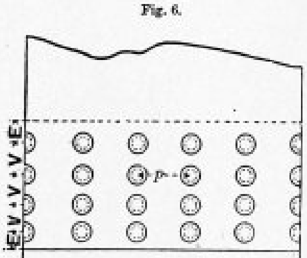


Fig. 3.

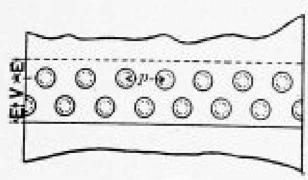


Fig. 7.

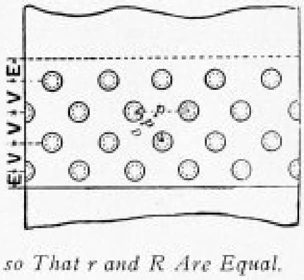
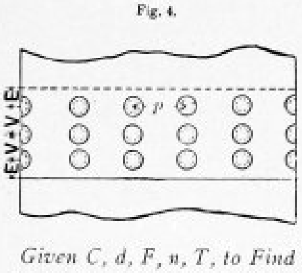


Fig. 4.



Given C, d, F, n, T, to Find p, so That r and R Are Equal.

Iron plates and iron rivets:

$$\frac{d^2 \times .7854 \times n \times C}{T} + d = p$$

Steel plates and steel rivets:

$$\frac{23 \times d^2 \times .7854 \times n \times C \times F}{4.5 \times S_1 \times T} + d = p$$

Given C, F, n, T, r, to Find p and d.

Iron plates and iron rivets:

$$\frac{r \times T}{(100 - r) \times .7854 \times n \times C} = d.$$

$$\frac{100 \times r \times T}{(100 - r)^2 \times .7854 \times n \times C} = p$$

Steel plates and steel rivets:

$$\frac{4.5 \times S_1 \times r \times T}{23 \times (100 - r) \times .7854 \times n \times C \times F} = d.$$

$$\frac{100 \times 4.5 \times S_1 \times r \times T}{23 \times (100 - r)^2 \times .7854 \times n \times C \times F} = p.$$

Fig. 8.

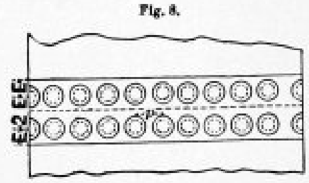


Fig. 11.

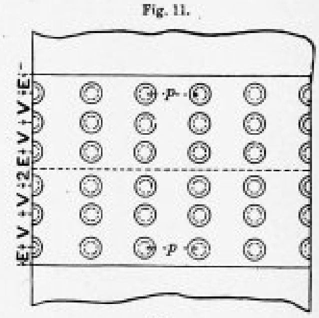


Fig. 9.

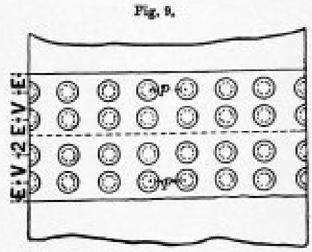


Fig. 12.

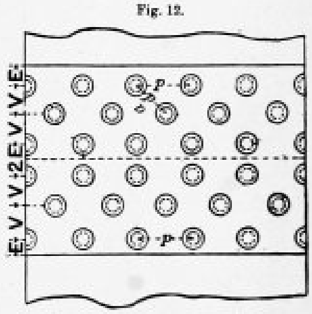
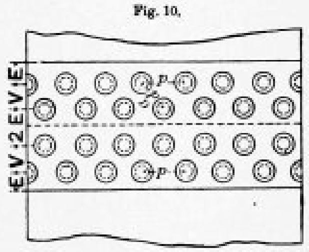


Fig. 10.



Iron plates and iron rivets, or steel plates and steel rivets when d is found first, then:

$$\frac{100d}{100 - r} = p.$$

Butt Straps.

Iron plates and iron butt straps or steel plates and steel butt straps:

Double-butt straps:

$$\frac{5 \times T}{8} = T_1.$$

Single-butt straps:

$$\frac{9 \times T}{8} = T_1.$$

For Distance Between Rows of Rivets, Etc.

Iron and steel:

$$\frac{3 \times d}{2} = E.$$

Chain-riveted joints, Figs. 2, 4, 6, 9, 11, not less than:

$$2 \times d = V$$

Zig-zag riveted joints, Figs. 3, 5, 7, 10, 12:

$$\frac{\sqrt{(11p + 4d)\ (p + 4d)}}{10} = V.$$

Diagonal pitch, Figs. 3, 5, 7, 10, 12:

$$\frac{6p + 4d}{10} = p_D.$$

To Determine the Working Pressure.

$$\frac{S \times \% \times 2T}{F \times D} = B.$$

Fig. 13.

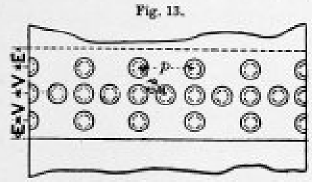


Fig. 16.

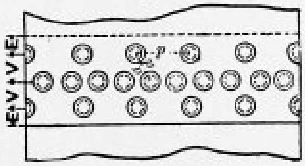


Fig. 14.

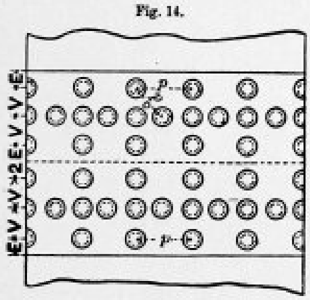


Fig. 17.

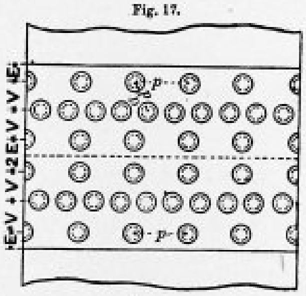


Fig. 15.

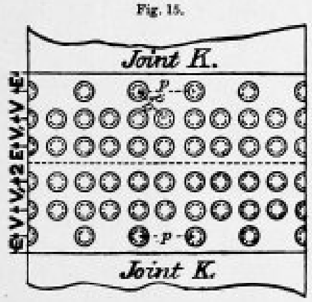
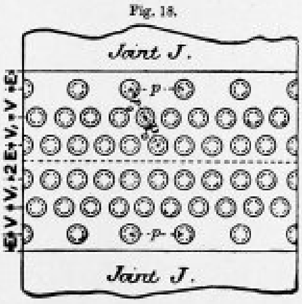


Fig. 18.



Chain and Zig-Zag Riveted Joints in Which Every Alternate Rivet Has Been Omitted in the Outer Row, or in the Outer and the Inner Rows, Such as are Shown by the Sketches on Page 174 and following.

Iron plates and iron rivets or steel plates and steel rivets:

$$\frac{100\ (p - d)}{p} = r$$

Iron plates and iron rivets:

$$\frac{100 \times d^2 \times .7854 \times n \times C}{p \times T} = R.$$

Steel plates and steel rivets:

$$\frac{100 \times 23 \times d^2 \times .7854 \times n \times C \times F}{4.5 \times S_1 \times p \times T} = R.$$

Iron plates and iron rivets or steel plates and steel rivets:

$$\frac{100\ (p - 2d)}{p} + \frac{R}{n} = R_1.$$

Butt Straps.

Where the number of rivets in the inner row is double the number in the outer row.

Iron plates and iron butt straps or steel plates and steel butt straps.

Double-butt straps:

$$\frac{5 \times T\ (p - d)}{8 \times (p - 2d)} = T_1.$$

Single-butt straps:

$$\frac{9 \times T\ (p - d)}{8 \times (p - 2d)} = T_1.$$

When the number of rivets in the inner row is the same as in the outer row.

Double-butt straps:

$$\frac{5 \times T}{8} = T_1.$$

Single-butt straps:

$$\frac{9 \times T}{8} = T_1.$$

Fig. 19.

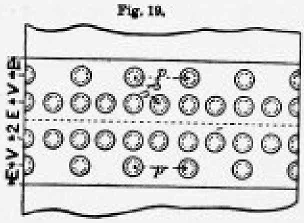
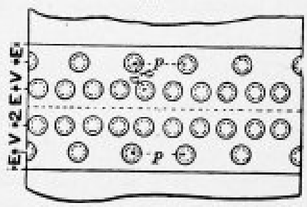


Fig. 20.



For Distances Between Rows of Rivets, Etc.

Iron and steel:

$$\frac{3 \times d}{2} = E.$$

Chain-riveted joints, Figs. 13, 14, 15, 19:

$$\sqrt{\frac{(11p + 4d)\ (p + 4d)}{10}} = V.$$

or

$$2 \times d = V.$$

The greater of these two values of V to be used. See note below.

For joint K (Fig. 15):

$2 \times d = V_1$ See note below.

Note.—The minimum value of V or V_1 for chain-riveted joints is given as $2d$, but $\frac{4d + 1}{2}$ is more desirable.

(To be continued.)

PERSONAL.

MR. THOMAS G. SMALLWOOD, formerly foreman boiler maker of the T. St. Louis & W. Railroad, located at Frankfort, Ind., has taken a position with the Chicago Pneumatic Tool Company, and will be located at their St. Louis office, 1405 Olive street, St. Louis, Mo.

R. E. MCNAMARA, formerly of Shawnee, Okla., has taken a position as supervising inspector of steam boilers with the Casualty Company of America, at Kansas City, Mo.

MR. HENRY MELLON, of Boston, Mass., has taken a position as foreman of the boiler manufacturing shop of the Bay City Iron Works, San Francisco, Cal. Mr. Mellon has had a wide practical experience in the boiler making industry.

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - - New York

Christopher St., Finsbury Square, London, E. C.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico........	$1.00	.10
Other countries in Postal Union..........	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

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 7,000 copies. We have no free list, accept no return copies, and issue only enough to supply the regular demand.

The Birth of a New Association.

The sixth annual convention of master boiler makers, held in Cleveland last month, marked an epoch in the boiler making industry, as it was not only the culmination of the careers of two vigorous and successful organizations, but it was also the inception of a broader and more vigorous line of activity by a new association which is to be known as the International Master Boiler Makers' Association. Perhaps the most noticeable, as well as the most pleasing, feature of the convention was the perfect harmony and mutual good will which prevailed among the members of both organizations. In view of the fact that these two bodies have been such sturdy rivals in the past, it was hardly to be expected that perfect agreement would be obtained on all matters pertaining to the consolidation. The result, therefore, is all the more gratifying, and shows very plainly the effect of the many months of hard work accomplished by the retiring officers and others who had the best interests of the organization at heart.

The selection of officers for the new association augurs well for its success. The president, both by reason of his position and the fact that he has been an untiring and zealous worker in the effort to bring about the consolidation, should prove a most able leader, while the selection of a secretary who is already in the business is a move which will do much to strengthen the organization and start the active work of the new association.

The Winners.

We extend our heartiest congratulations to the successful competitors in the recent contest for the Champion prizes. The first prize was awarded to Mr. James Crombie, Hamilton, Ont.; the second to Mr. J. T. Goodwin, of Richmond, Va.; and the third to Mr. T. C. Best, of Chicago, Ill. The papers which were awarded first and second prizes, respectively, are published on another page of this issue, and the one which was awarded third prize, together with some of the information contained in a number of the others will be published in a subsequent issue.

The Shearing Strength of Rivets.

A number of articles which we have received recently on subjects involving the calculation of the strength of riveted joints have brought out the fact that several different values are being used to-day for the shearing strength of iron and steel rivets, both in single and in double shear. For single shear, values are assumed varying from 38,000 to 45,000 pounds per square inch, while the strength in double shear is assumed to be anywhere from 75 to 85 percent excess over that in single shear. This is undoubtedly due to the fact that different authorities who prescribe rules for the construction of steam boilers have designated these values at different times, basing their recommendations upon data taken in tests on wholly different grades of steel. This data, while representing accurately the conditions at the time it was taken is frequently not brought up to date, and so we find designers applying to the material used for boiler rivets to-day values which were obtained some years ago in tests made on an entirely different grade of material.

The material which is used for boiler rivets to-day is of a very uniform grade, the shearing strength of which has been very definitely determined. Perhaps the most reliable figures which we can quote on this point are those obtained by members of the Master Steam Boiler Makers' Association about a year ago, and which were published on page 316 of our November, 1906, issue. These are as follows:

	Pounds Per Square Inch.
Iron rivets in single shear...............	42,000
Iron rivets in double shear...............	80,000
Steel rivets in single shear...............	45,000
Steel rivets in double shear..............	88,000

The above results have been verified by other recent tests, and may be considered as accurately representing the value of the shearing strength of the iron and steel which is used in boiler rivets to-day.

Our Supplement and Directory.

We are presenting to our readers this month in connection with our annual convention issue two new features which we hope will be found of much value. One of these is the Boiler Shop Equipment and Supply Supplement on pages 179 to 200, and the other a buyers' directory, published separately in vest pocket size. The former has been compiled in order to give the busy manufacturer or foreman in compact and comprehensive form the most interesting facts regarding all the latest tools and supplies on the market for the boiler making industry, while the latter gives in classified form complete information regarding where to buy such supplies.

COMMUNICATIONS.

The Cause of Boiler Explosions.

EDITOR THE BOILER MAKER:

The writer has noticed a great many articles written on the cause of boiler explosions. In my thirty-five years of experience following the boiler business I have seen some bad explosions and many boilers badly ruptured. Locomotive boilers are just as liable to explode by being overloaded as any other type. Also locomotive boilers that are made to run on level track would be dangerous to be used on heavy grades, as their crown sheets are too high on the back end. By being so constructed there is danger of dropping the back end of the sheet when pitching over a heavy grade, after going the lowest limit on water in order to get there with a heavily loaded train.

I had the opportunity to save more than one engineer on that point after getting the percent on the grade and the slope on the crown sheet. It proved that the first two rows of radial stays were nearly bare of water when in this position, and when burning oil, with a brick arch, it did not look safe. It really seems very curious to mention it, but I have had boiler makers, who claim to be first-class mechanics, argue that all locomotive fire-boxes should be as high on the back end as on the front end. A man like this, who is trusted to put in a new fire-box and has his way, is a dangerous man to employ; it is all shouldered on to the engineer if anything goes wrong, and as he and the fireman have very likely been killed, there is no one to tell the tale.

Now, on stationary boilers, the cause of some explosions may be oil on the bottom of the shell, mud bagging, working too far over capacity, or having a bridge-wall forming a choke-draft, thus getting a double action of heat in one place, which evaporates the water much faster than in other parts, and so forming a steam pocket which bags or ruptures the boiler, Some times these steam pockets cause a bad explosion, then if the engineer is killed they blame him, or else the man that made the boiler—that someone had said that the boiler was weak. I had several owners of plants say to me that their boiler was not properly made—the boiler makers drifted the holes and made them crack out. After running the boiler a while, in order to find the cause, I found that they fed the boiler in the blow-off at the back tube sheet and had 4 inches of solid incrustation or scale. This would not allow any circulation where the hottest part of the fire struck the sheet and caused fifteen holes on each side of center to crack. At another place where they did not use oil, but burned shavings, with a forced draft and blower, a dead wall 30 inches wide, situated in the back part of the furnace, caused a double action of heat, which bagged a new boiler that had a ½-inch shell and had been running only three months. They wanted to blame it on the maker, saying that the material was not good.

Now, my advice is to always have enough boiler power and don't overload it. Have a good engineer, if he does cost more money, he is the cheapest and safest to employ, also have a competent inspector examine the boiler twice a year.

UNCLE JOE.

Safe Flanged and Dished Heads.

EDITOR THE BOILER MAKER:

In your issue for May there is on page 129 an article from "Engineering Record" called "The Design of Heads for Tanks Under Pressure," which describes the method used for obtaining the size of the blank circular plate required for a dished and flanged head, and one way—not the best way—of dishing and flanging this circular plate into a head, namely, that of flanging by a spinner and then adjusting the diameter of the newly flanged head to correct size required by striking a fuller held against the knuckle of the flange with a heavy sledge. The "Engineering Record" should know that such heads can be and are dished and flanged in one stroke to correct diameter in moulds and dies fitted to powerful hydraulic machines without the use of fuller and sledge.

Admitted that the spherical head will retain its form under internal and external pressure if strong enough to resist the pressure, and it won't if not strong enough, we can claim the same for dished and flanged heads when made properly and of suitable material.

The trouble with the heads or ends in the still and cooker described in the above article, was poor workmanship or poor figuring, or both. If the heads in the still and cooker had been made of material thick enough to withstand the strain placed on them—as must be done with spherical heads—or suitably braced to make up for lack of thickness, they would have retained their form without fatalities or loss resulting. Since dished and flanged heads as strong as spherical ones can be placed in vessels at the same or less cost, why should we lose the comely appearance and the, in many cases absolutely necessary, saving in space of the former?

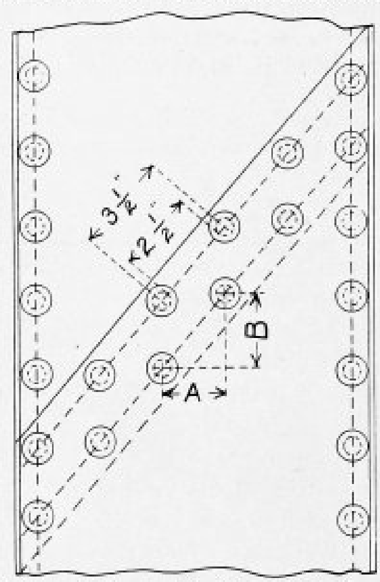
Both spherical, dished and flanged heads are manufactured to-day that will do the service required of them, sparing the need of record of fatalities and dread of calamity, mentioned in the above article as resulting from the use of dished and flanged heads.

GEO. REEVES.

An Example of the Diagonal Seam.

EDITOR THE BOILER MAKER:

I submit the following joint which has an efficiency of more than 100 percent. The object is to cross the sheet diagonally so that the space between the holes multiplied by the number of spaces will be equal to the full width of the plate. Assume



a lap joint, distance between the holes 2½ inches, thickness of plate ⅜-inch, T. S. of plate 60,000 pounds and S. S. of rivets 40,000 pounds.

$2\frac{1}{2} \times \frac{3}{8} \times 60,000 = 56,250.$

$56,250 \div 2$ (the number of rivets to the 2½ inches section) $= 28,125$ pounds, the shearing strength required in one rivet in single shear

$$\sqrt{\frac{28,125}{40,000 \times .7854}} = .9462 \text{ inch, diameter of rivets.}$$

One inch being the nearest standard diameter above .9462, take 1 inch for diameter of hole.

$1'' + 2\frac{1}{2}'' = 3\frac{1}{2}''$ pitch.

Multiply the distance between the holes by 100 and divide the product by the efficiency required in the joint to find the distance A.

From the square of the pitch subtract (A^2) and the square root of the remainder equals B.

Pitch $3\frac{1}{2}$ inches, distance between the holes $2\frac{1}{2}$ inches, efficiency required 110 perecent.

$$\frac{5}{2} \times \frac{100}{110} = 2.272 = A$$

$$3.5^2 = 12.25$$

$$A^2 = 5.162$$

$$7.088 = B^2$$

$$\sqrt{7.088} = 2.662 = B$$

As this joint has the same propensities as a girth seam, the lap-joint on light plates is sufficiently good and the crimp which has proved so disastrous on a longitudinal lap joint is practically eliminated. JOHN A. DOWD.

QUERIES AND ANSWERS.

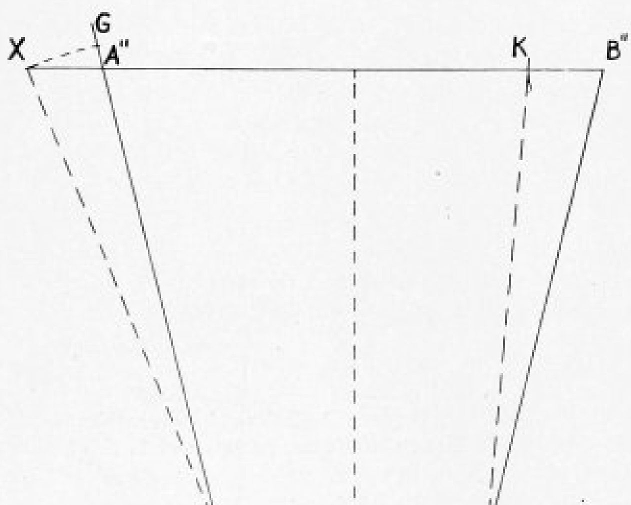
Discussion and answers to the questions published in this column are solicited from our readers. All such contributions will be paid for at our regular rates when acceptable for publication if they are accompanied by the name and address of the writer.

Q.—Will some of the readers of THE BOILER MAKER give in detail the layout of a Y breeching? TRAMS.

A.—See page 170.

Q.—In the article on the "Lay Out of a Four-Piece 90-Degree Elbow with Large and Small Ends on Each Course," by J. H. Sheridan, on page 96 of the April issue of THE BOILER MAKER, how are the distances $A''X$ and $B''K$ obtained? ELK.

A.—To obtain the distance XA'' run the line $C''A''$ some distance above the line XB'' and then set the dividers with



one leg on A'' and with a radius equal to twice the thickness of the iron locate the point G. Then, with one leg of the dividers on C'' and a radius equal to $C''G$, draw the arc intersecting XB'' at X. Then with one leg of the dividers on B'' and a radius equal to $A''X$ draw an arc to the point K.

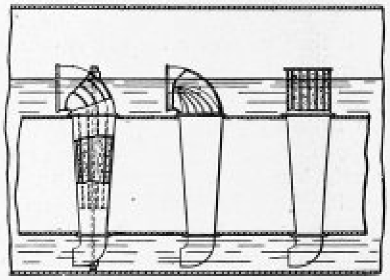
SELECTED BOILER PATENTS.

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.

842,024. STEAM BOILER. Harry Schofield, of London, England, assignor of one-third to Sidney John Ross and one-third to Oliver Prescott MacFarlane, of London.

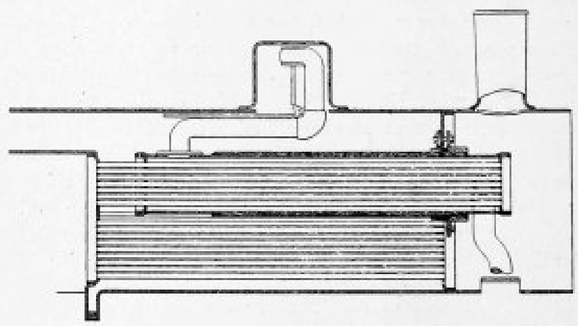
Claim.—In a steam boiler, the combination of a longitudinal flue, cross tubes for water arranged transversely of the said



flue and open at top and bottom, and filling means extending approximately from the top to near the bottom of the cross tube for confining the water to the circumference of such cross tubes, so as to form a thin annular body of circulating water inside said cross tubes. Eight claims.

843,315. SUPERHEATER FOR LOCOMOTIVES, Henry V. Willie, Philadelphia, Pa., assignor to Burnham, Williams & Co., of Philadelphia, Pa., a firm.

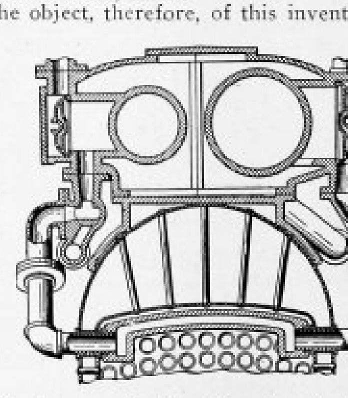
Claim.—The combination of a boiler casing, longitudinal tubes therein, a super-heater located partly within the boiler



some of the tubes of the boiler passing through the super-heater, with a pipe connecting the super-heater with the body of the boiler, and an outlet-pipe from the super-heater. Nine claims.

847,713. REHEATER. George E. Wilson and William J. Frawley, of Stillwater, Minn.

Abs.—The object, therefore, of this invention is to provide



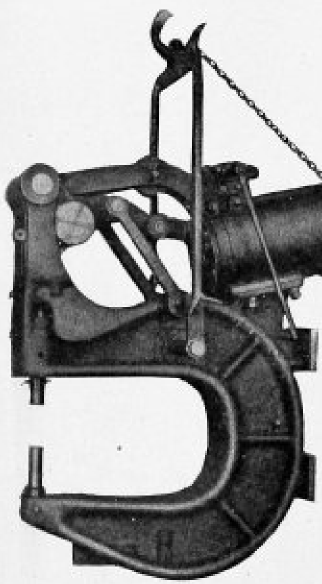
means for drying or reheating the exhaust steam of the high-pressure cylinder before it enters the low-pressure cylinder. Two claims.

Boiler Shop Equipment and Supply Supplement.

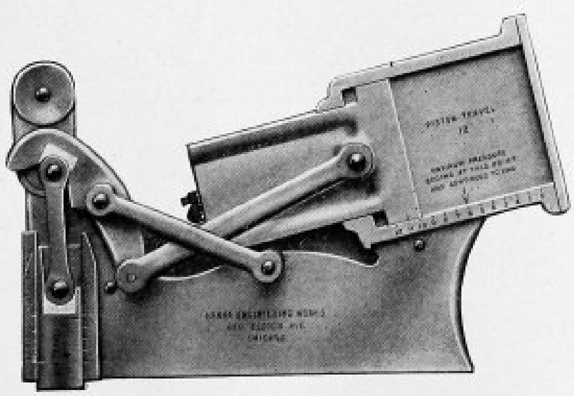
In the following pages may be found the latest information concerning some of the most useful and best known tools and other items of equipment for boiler shops as supplied by the manufacturers in their most recent trade publications.

The Hanna Jaw Riveter.

The Hanna portable jaw riveter is a pneumatic tool, but it operates on a slightly different principle from the ordinary toggle joint or lever machine. The link motion in the Hanna



riveter is so designed that during the first part of the piston stroke the jaws or dies are brought together rapidly almost wholly by the toggle joint action. During the last half of the piston stroke the dies approach very slowly, the pressure which they exert being nearly uniform. During this part of the stroke the pressure is applied from the piston almost entirely by the



lever action. The scale giving the die travel for equal spaces of piston travel shows that out of the total travel of 4 inches about 3½ inches are accomplished in the first half of the piston stroke, the remaining half inch being accomplished at a nearly constant slow rate of speed and steady pressure.

On account of the considerable distance through which a maximum known pressure is exerted a careful adjustment of the distance between the dies for different lengths of rivets is not needed, and there is no necessity for striking a rivet more than once. Thus the action of this machine is similar to that of an hydraulic or "bull" machine.

The Hanna riveters are manufactured by the Hanna Engineering Works, 820 Elston avenue, Chicago, Ill.

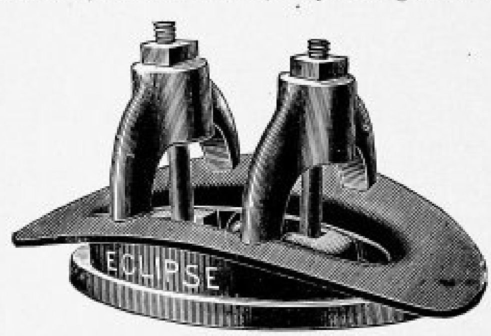
Faessler's Improved Sectional Beading Expander.

In the sectional expander shown below, the ordinary round tapered mandrel has been replaced with an octagon tapered mandrel. This gives each section of the expander a bearing equal to the full size of its back face, therefore, greatly reducing the wear on the sections and increasing the life of the

tool. It is also claimed that this mandrel does not have the tendency to fly out of the expander, which is often found with a round mandrel. The tool may be furnished with either a rubber or steel spring as desired. J. Faessler Manufacturing Company, Moberly, Mo., are the manufacturers.

Eclipse Manholes.

The value of different types of manholes depends upon the strength with which they reinforce the plate where the hole has been cut, and also upon the tightness of the joint between the manhole and cover. The customary way of forming the Eclipse manhole, illustrated below, is by turning back a flange

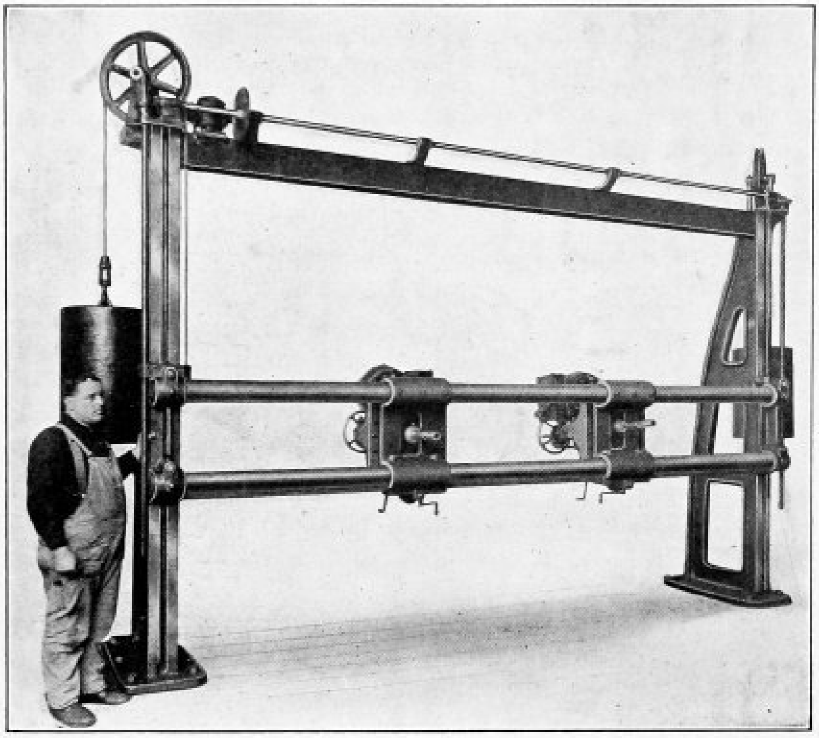


around the hole by means of special machinery designed and patented by R. Munroe & Sons, Pittsburg, Pa., who are the manufacturers of this specialty.

On this machine the flange is turned back until it is exactly at right angles to the plate. The rough edge is then planed, forming an absolutely smooth and level seat for the cover. The cover has an outer lip, or rim, so that a groove is formed into which the flanged part of the manhole fits. A composition gasket is placed in this groove, thereby forming a positive and durable steam-tight joint. Where it is impracticable to turn down the flange on the boiler plate itself a separate flange saddle is made in exactly the same manner as the flange is turned down on the boiler shell. This saddle is then riveted directly to the shell.

The Dallett Motor-Driven Boiler Shell Drill.

A motor-driven drill, designed for the special purpose of taking advantage of high-speed steel, has been placed on the market by the Thomas H. Dallett Company, of Philadelphia, Pa. As can be seen from the illustration there are two end housings, on the front face of which carried by brackets are two 5-inch bars, upon which are mounted two independent motor-driven drill heads balanced by a weight at each end. The drills have a vertical range of 6 feet, being raised and lowered by means of screws actuated by a motor on the top rail of the machine. An especial feature of this machine is the central piston of the spindle, which is not only between the bearings of the drill head but also between the bars, so that the pressure of the drill against the work has no tendency to set up torsional or eccentric stresses in the drill-head bearing. The spindle speeds range from 80 to 160 revolutions per minute. The spindle is 1 13/16 inches in diameter, and is bored for No. 4 Morse taper. It has a traverse of 18 inches and a perpendicular range through an arc of 15 degrees, to permit drilling rivet holes radially from the center of a boiler, which is placed on rollers in front of the machine. The machine has a range of feeds from .005 inch to 1/16 inch per revolution. In the lowest position of the carriage the center of the spindles are 21 inches from the floor and the highest position 7 feet 6 inches. The distance between the housings is 14 feet, and the distance between spindle centers when the drill heads are in their outermost position is 12 feet.

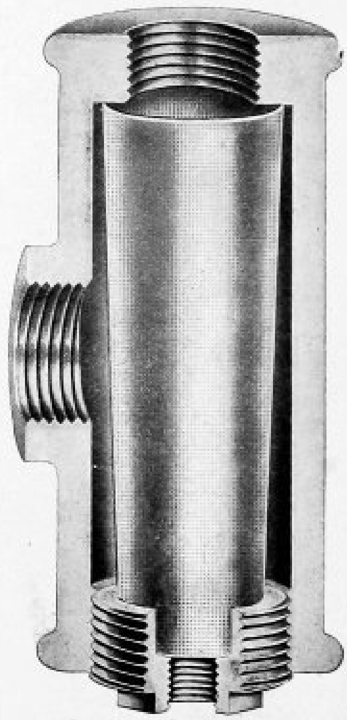


The Victor Boiler Rivets.

The Victor boiler rivets, manufactured by the Champion Rivet Company, Cleveland, Ohio, are made of open-hearth steel of such composition as to insure strength, toughness and ductility. The average results of a number of tests made on these rivets show the elastic limit to be 35,154 pounds; the average tensile strength 57,195 pounds, shearing strength in single shear 44.477 pounds, shearing strength in double shear 91,440 pounds, the elongation in 8 inches 31.9 percent, and the reduction of area 65.5 percent. These same specimens show by chemical analysis the following properties: Average percent of phosphorus, .015; manganese, .46; sulphur, .032; silicon, .005; carbon, .11. The Victor rivets are made in all of the ordinary styles, cone head, button head, steeple head and countersunk.

The Wright Filter.

The Wright filter, herewith illustrated, is designed and constructed by the Wright Manufacturing Company, Detroit, Mich., for use in connection with water pipes, boiler-feed and meter systems for the purpose of eliminating sand, scale, vegetable and floating substances from the water which would otherwise reach the boiler or interfere with the free operation of water meters.

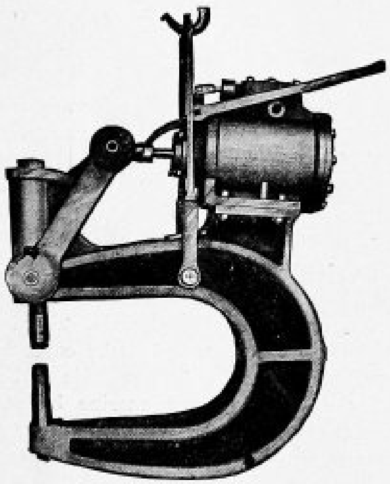


The filter tube is brass and many times larger in area than the inlet. A simple blow-off valve screwed into the opening in the plug may be opened occasionally in order to free the filter from accumulated foreign matter. The filter tube itself is easily removed by unscrewing the plug to which the tube is attached. The outlet is at the side about half way between the top and bottom.

Allen Pneumatic Riveter.

The John F. Allen Company, 370 Girard avenue, New York City, claim to be the pioneers in the manufacture of power riveters, since their first patents were applied for by Mr. Allen as early as 1883. Since that time this company has produced a great many different types of riveters designed to keep pace with the progress in this line of machinery. One of their latest tools is the jaw riveter shown below. This machine is of the toggle joint type, in which the lower ends of the larger levers are attached to fixed centers of the frame, and the end of the short central lever is attached to the rim, which has a die head screwed into the lower end. This latter arrangement permits any desired change in the distance between dies requird by different classes of work.

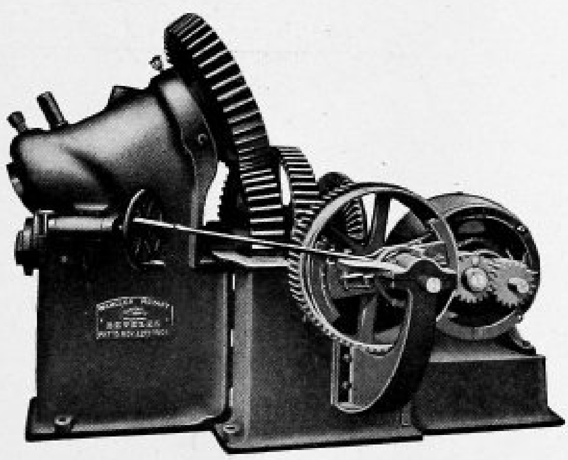
One important improvement on this machine is an automatic cut-off arrangement which forces the valve back over the port



opening and prevents the air from entering the cylinder when the machine is not in operation. Without this the air would escape by the piston through the exhaust, causing a constant waste or leakage. The full air pressure is maintained in the valve chest while at the same time the necessity of shutting off the air from the riveter in order to prevent waste is avoided. This has resulted in such marked economy that many concerns who are already using tools which were manufactured before this device was invented have had it applied.

The Wangler Rotary Beveling Shears.

In the Wangler rotary beveling shears, an illustration of which is shown herewith, the cutting is done by means of two hardened tool steel cutters, which revolve in opposite direc-

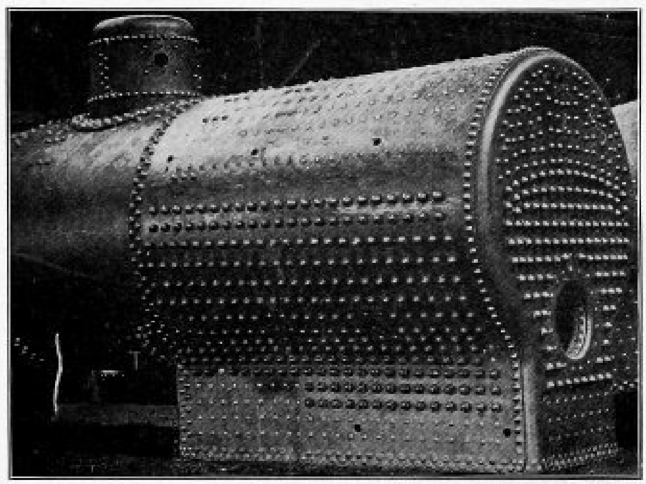


tions. The edges of the cutters are milled in order to make the machine self-feeding. Both cutters are reversible, so that when one edge becomes dull the opposite edge may be used. The upper cutter is fastened flush to its shaft, so that no projecting nut or fastening will interfere when shearing angles or flanged pieces. The shaft on which the lower cutter is mounted is horizontal, the upper cutter shaft being inclined at an angle of 30 degrees to it. It is claimed that this arrangement reduces the end thrust on the lower shaft. The upper cutter shaft is carried in an iron sleeve or cage, which is brass bushed. The driving pulley is placed next to the frame of the machine, the outer end of its shaft being supported by a substantial outboard bearing. In the motor driven machine, this belt driven pulley is replaced by one which has a gear on its face. The motor is then mounted back of the machine and drives this pulley by means of a pinion, the clutch mechanism being retained, giving the same control for both belt or motor driven machines. The Scully Steel & Iron Company, of Chicago, Ill., handle this machine.

The Tate Flexible Stay-bolt.

When flexible stays first came into use it was customary to install then only in the breaking zone of fire-boxes. Many railroads are now, however, installing flexible stays, as shown by the illustration, over the entire side sheet, back head and throat sheet.

The Tate flexible bolt, which was the type used in this case, is of the round-head type. The head has a spherical bearing on



a separate sleeve, which is screwed into the outside sheet. The sleeve has a flaring mouth at the water space end, and a machine-made surface on the outer end for the cap bearing. The cap itself is of drop-forged steel, carefully machined to seat itself on the sleeve bearing and make a steam-tight joint without the use of a gasket. A clearance is left between the bolt head and seat, so that the bolt may free itself from incrustation and have an opportunity for longitudinal expansion. The only machine work done on the surface of the bolt is to cut the threads at the fire sheet end where it is screwed into the fire sheet and riveted over. The Tate flexible stay-bolt is manufactured in many different styles suitable for different purposes by the Flannery Bolt Company, Pittsburg, Pa.

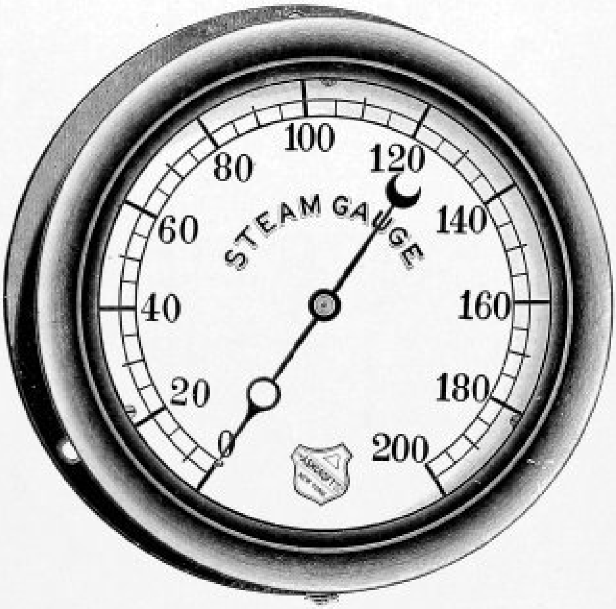
U. S. Standard Punches.

I. P. Richards, Providence, R. I., is the manufacturer of the United States standard punches and dies for boiler, bridge,

ship and structural work. The heads of these punches have a large diameter, and with the forged steel couplings make a firm and substantial punch for heavy work. For punching large holes a double shear cut punch is made. The dies are made with a beveled shoulder and are held firmly to the bed by a screw coupling. The punch is secured to the stock in a similar manner, and thus the die and punch are always brought into alinement.

The Ashcroft Auxiliary Spring Steam or Pressure Gage.

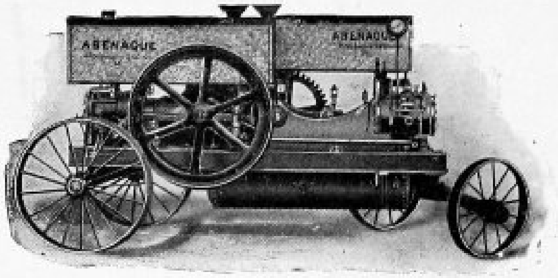
This gage has been designed for the pupose of providing an accurate, sensitive and durable gage that cannot be subject to the inaccuracies caused by the permanent set of the spring,



such as frequently occur in all gages of the single or double spring type. Its principal feature is the auxiliary spring which is an independent co-operationg spiral spring applied to the free end of the single tube spring which dispenses with the second tube common to all double spring gages and reduces the number of joints subject to friction and wear between the spring and indicating mechanism to the least possible number (2.). The tube spring is made sufficiently short to be self-draining when pressure is off the gage. Quickness of action and sensitiveness to the slightest change in pressure are claimed for this gage by its manufacturers, the Ashcroft Manufacturing Company, 87 Liberty Street, New York.

The Abenaque Portable Air Compressor.

The Abenaque Machine Works, Westminster Station, Vt., are the manufacturers of a portable gasoline-driven air compressor, which finds a wide usage in structural steel and sheet-metal field work. As can be seen from the illustration, the



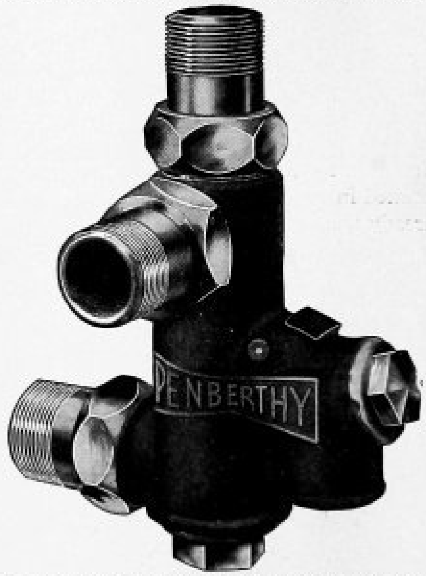
engine and compressor are mounted in line on steel beams and connected by large spur gears of such size as to allow both engine and compressor to run at their most efficient speeds. The gasoline tank and air receiver are located under the beam. The whole outfit is mounted on wheels and is entirely self-contained, so that it is ready for use immediately upon its arrival at the location of the work.

The compressor is provided with an unloading device, which may be set for any desired pressure, and after this is exceeded prevents further action of the compressor valves and allows the engine to run without load. The cooling of the compressor is so accomplished that only a small amount of water is required, as the water is cooled in thin, flat tanks, located above the engine and compressor, thus making it possible to use the same water repeatedly.

These machines are furnished suitable for any desired pressure and in many different sizes. The most common is, however, an 8 by 8 compressor driven by a 12-H. P. engine. This will furnish 75 cubic feet of free air per minute at a pressure of 100 pounds per square inch.

Penberthy Automatic Injector.

The automatc injector has come into use to meet the requirements of the most exacting conditions. For instance, on traction engines or road rollers, where the current of water, which is being forced to the boiler, is liable to be suddenly broken by a jar or jolt, or in a marine boiler, where a sudden roll may throw the sea cock out of water for a moment, an automatic injector will pick up the water and again

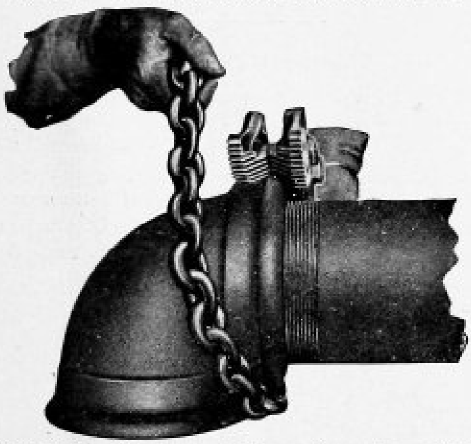


establish the current to the boiler without the manipulation of a single valve. The automatic injector herewith illustrated is manufactured by the Penberthy Injector Company, Detroit, Mich., and is designed to deliver under these exacting conditions feed water from 160 to 212 degrees Fahrenheit, according to the temperature of the feed water and steam pressure. It is composed of the following number of parts in addition to the casing: Steam jet, suction jet, delivery jet, plug, tail pipe, coupling nut, overflow hinge, overflow valve and overflow cap, making nine in all. The interior of the injector is readily accessible, and the parts are all standardized, so that repairs can be quickly and easily made if necessary.

The Ideal Chain Wrench.

It is particularly desirable in a boiler shop to have a wrench which may be used on any kind of pipe or fitting without danger of slipping. It is claimed that the Ideal wrench, manufactured by Kroeschell Brothers Company, 29-55 Erie street, Chicago, Ill., will answer the many requirements which come up in this sort of work. One of the most difficult cases is that of fitting the blow-off elbow under a boiler where the space is cramped. The accompanying illustration shows how easily this wrench grips an elbow. It can be seen that the wrench has four biting surfaces on the jaws, flat teeth for pipe, and V shaped jaws for irregular surfaces. By gripping an elbow on the bead, as shown in the figure, as firm a hold may be obtained as on straight pipe with an ordinary wrench.

An improved chain adjustment insures that the slack of

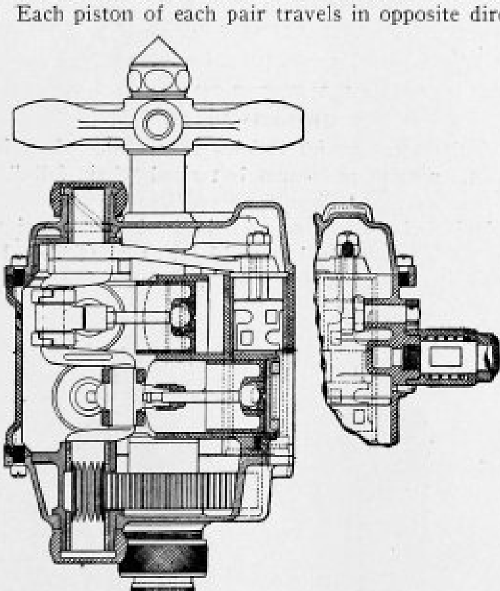


the chain will be taken up, giving a firm grip. An automatic chain lock is also provided, so that the chain cannot become loose or fall out of the lock, even when the same is in an inverted position. The entire mechanism of the tool is concentrated in the jaws, which may be retempered and reground an indefinite number of times, thus prolonging the life of the tool.

The Little Giant Drills.

NO. 1 CLASS "H" CORLISS VALVE TYPE.

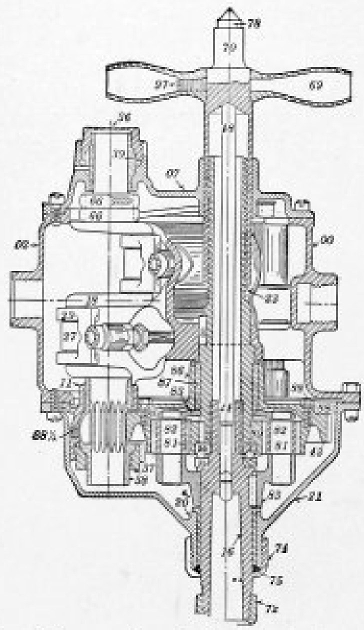
This type of drill is manufactured both reversible and non-reversible. It is of the balanced piston type and consists of four single acting cylinders arranged in pairs, each pair of pistons being connected to opposite wrists of a double crank shaft. Each piston of each pair travels in opposite directions



at all parts of the stroke, giving a smooth running action. The balanced piston valves are set to cut off at five-eighths stroke to insure economy in the use of air without sacrificing speed or power. The valves and reversing mechanism are constructed with a minimum number of parts, and in minimum number of air passages to restrict the passage of air from the cylinders after having performed its work. This machine has a 4-inch feed, a spindle speed of 220 revolutions per minute, when running light, with 80 to 100 pounds air pressure, and a total weight of 49 pounds. It is adapted to drilling up to 2 inches and reaming and tapping up to 1¼ inches in diameter.

NO. 2 CLASS "L" CORLISS VALVE TYPE.

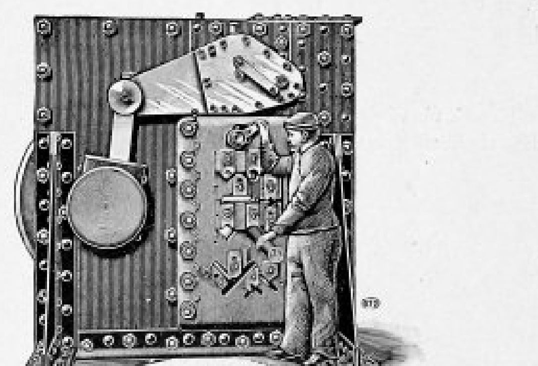
One of the most prominent claims made for this drill is simplicity. It has but one eccentric, which is forged solid on the crank. The valves are cast iron and operate in bronze bushings, each being driven by a tongue and groove in the head, the same as the valves in a Corliss steam engine. This drill



has a feed of 4 inches and a spindle speed when running light with 80 to 100 pounds air pressure of 400 revolutions per minute. Its total weight is 33 pounds and it is adapted for drilling up to 1¼ inches; or for tapping, up to 1 1/16 inches. All the "Little Giant" pneumatic drills are manufactured by the Chicago Pneumatic Tool Company, Chicago, Ill.

Bar Cutters.

In these days of keen competition it is not sufficient for a boiler maker to keep a stock of bars and different shapes on hand, he must also provide for facilities for cutting these bars

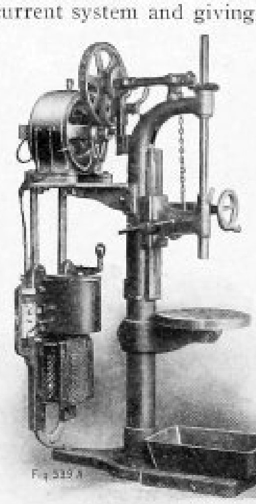


off immediately. The value, therefore, of the machine which we herewith illustrate, is evident from the fact that it has openings for all kinds of round, square, flat, angle and tee bars, and that all these different shapes can be cut off at the very moment they come from the rack. This enables one to use these bars immediately, and not to bring them to a cold saw, where they have to wait for their turn at the saw, which is a comparatively slow proceeding.

These bar cutters are built by Henry Pels & Co., 68 Broad street, New York City, for either hand or belt power. The former are made with all kinds of interchangeable knives, while the power machines are built with openings for the different sections that have to be cut. The frame of these machines consists of heavy steel plates; they are therefore very durable, and can even be placed in the open yard. The cutter is fitted with holding-down plates, hand starter and counterbalanced plunger, and, if desired, a foot brake can be arranged.

Motor Drive for a Sensitive Drill.

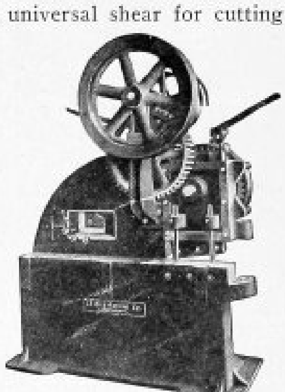
In order to meet the requirements for a variable speed drive for machine tools in modern factories, the Crocker-Wheeler Company, Ampere, N. J., have designed and are prepared to furnish a field weakening motor suitable for operating on a two-wire direct current system and giving speed ranges up to



3 to 1. This type of motor is used where conditions do not warrant the installation of a multiple voltage variable speed system. The accompanying illustration shows the motor applied to a sensitive drill press. The construction of the motor combines simplicity and accessibility. The motor is of the multipolar type with a round frame, and has feet for attachment to a railbrace or bracket. The bearings are supported from the frame by strong curved arms. The motors ordinarily furnished are of the open type in order to allow free ventilation and accessibility to the inside of the machine. This type can, however, be supplied with gridiron covers to protect the interior from mechanical injury caused by flying chips and the like.

A Universal Angle and Plate Shear.

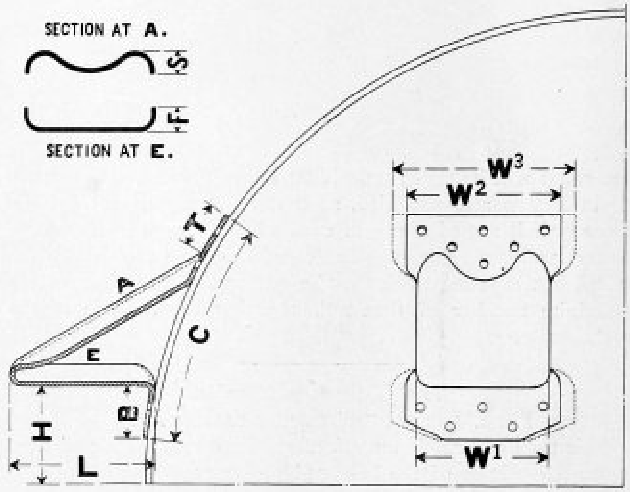
The C. C. Wais Machine Company, of Cincinnati, Ohio, are manufacturing a universal shear for cutting plates and bars,



and also angles with even or uneven legs. The machine may also be readily changed into a punch. Both the plate and angle shears are driven from one pulley and can be operated singly or both at the same time. The angle shear runs at an angle of 45 degrees. The clutch stops at only the highest point, and the clutch lever is universal so that it may be turned to any position to suit the operator. The machine is very strongly geared and has been designed to save floor space.

The Roe Boiler Lug.

The Roe boiler lug is manufactured by the Glasgow Iron Company, Pottstown, Pa., from the best open hearth steel plate. It is designed to bring the metal in direct line with the strains. This is accomplished by making the upper or compression member corrugated and the bottom member flanged on the sides for stiffness, but flat on the bottom to admit of the use of rollers. The riveting which joins these lugs to



the shell is designed with a factor of safety greater than 5 to give efficiencies of from 82 to 86 percent in the shell. The lug is made in five sizes, covering all boiler diameters from 30 to 84 inches inclusive.

Chain Hoists.

One of the most useful articles in a boiler shop is the chain hoist, or as more commonly termed "chain falls." Fig. 1 shows one of the earliest forms of improvement in chain hoists. This hoist would sustain the load at any point and was a great improvement upon old forms of tackle. Fig. 2 shows a modern type of screw hoist which lifts a load very

FIG. 1.

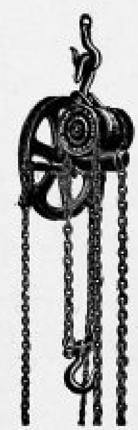


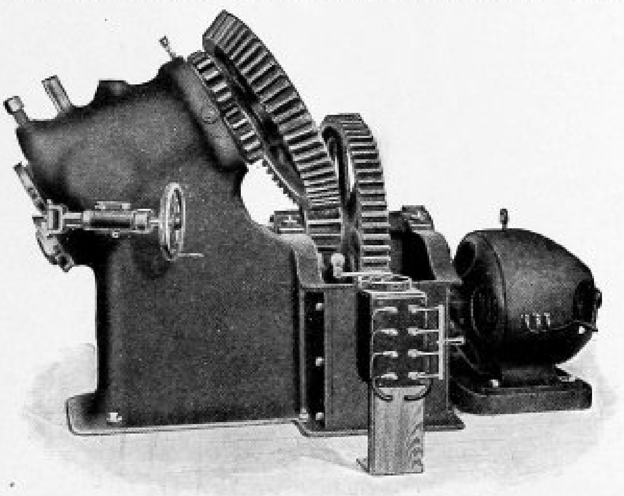
FIG. 2.

easily and with comparative speed. It operates upon the worm and worm gear principle. The end wheel drives a steel screw which operates the phosphor bronze worm gear. On the shaft in this gear two pocketed chain wheels are fitted, which, in revolving with the gear, raise the load chain. The working parts are always thoroughly immersed in oil, being contained in an oil-tight case. The thrust screw operating against a bronze washer permits the operator to regulate the speed in lowering, and also to take up the wear of the moving parts.

A patent chain guide permits the operator to stand back from under the load and operate the hoist without producing an exceptional amount of friction, thus eliminating danger without sacrificing power. These hoists are manufactured by D. Round & Son, Cleveland, Ohio.

The Lennox Rotary Bevel Shear.

The Lennox rotary bevel shear is designed to bevel steel of any thickness from 1/8 to ¾-inch. The work is done by means of circular blades which rotate in opposite directions, holding and feeding the plate while it is being cut. These



blades are made from the finest grade of tool steel carefully turned and milled. The upper blade has a double edge, so that in case of damage to one cutting edge it may be easily reversed. The shear blades are properly adjusted before leaving the factory, the top blade overlapping the lower 1/16-inch. If less bevel is required, the lower blade may be set out until the proper amount of clearance is obtained. As a general rule, the distance between the blades should be about one-fourth the thickness of the metal which is being cut. This tool is furnished with either a motor or belt drive, and it may be used for beveling both in-and-out curves of a segment, angles, and such difficult work as flanged boiler heads, manholes, saddles, etc. It is manufactured by Joseph T. Ryerson & Son, Chicago, Ill.

The Thor Pneumatic Hammers.

The Thor hammers are of two general types, sectional views of which are presented herewith. Fig. 1 shows the duplex

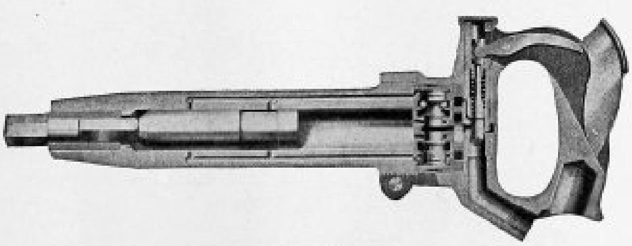


FIG. 1.

valve chipping and calking hammer in which the air enters a chamber at the rear of the cylinder and presses apart two valves, allowing the air to enter behind the piston. The piston is driven forward until the port near the end of its stroke is uncovered. This admits air to the outer side of the valves, and as the area of the outer side is larger than that of the inner, the excess pressure causes the valves to close. Air is then admitted to the opposite side of the piston, driving it back until the port near the end of the stroke is again covered, when the operation is repeated.

The duplex valves, on account of their extreme lightness

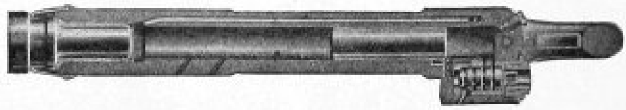


FIG. 2.

and double action, will throw open the inlet very quickly and leave a large exhaust area.

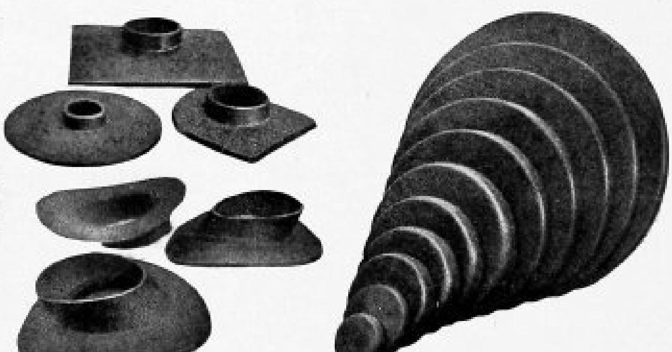
The main novelty of the Thor long stroke riveting hammer (Fig. 2) lies in its one piece construction. The handle, barrel and valve chamber are all in one solid piece of steel forging.

The main valve lies parallel with the main bore, but is not directly operated with the air in the downward stroke. When the plunger returns it opens what is termed the auxiliary valve. This valve lets in a slight amount of air which starts the plunger downward. After a short travel the main valve opens and lets in a great volume of air close to the plunger. This hammer, therefore, from a gentle start gets an extremely forceful and quick striking blow and quicker return, with very little vibration.

The Independent Pneumatic Tool Company, of Chicago, are the manufacturers of all the Thor pneumatic tools.

Machine Flanging for Boiler Work.

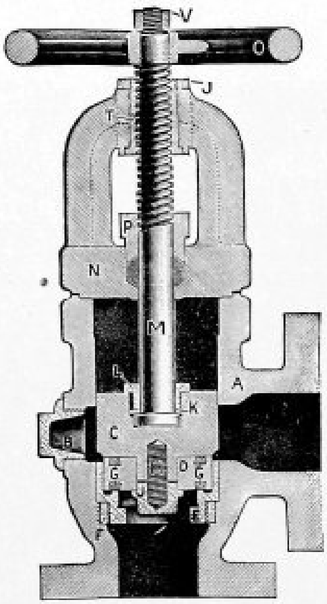
The accompanying illustration shows a few of the many different forms of flanging which are commonly being carried on by the Glasgow Iron Company, Pottstown, Pa. All sizes of boiler heads, either flat or dished, are flanged to any desired radius. Smaller work, including standard flanges for threaded



pipes, manholes, handholes, and various forms of pressed work, which take the place of expensive bronze or steel castings are also done. Manholes are flanged in three styles, plain, reinforced and banded, all having machine faced joint seats. In plain flanged manholes the thickness of metal is somewhat reduced on the face. This is compensated for in the banded manholes by a band shrunk on to the flange and secured with studs. The reinforced manhole is most frequently used on dished heads or where a broad joint surface and extra strength are required.

An Improved Blow-off Valve.

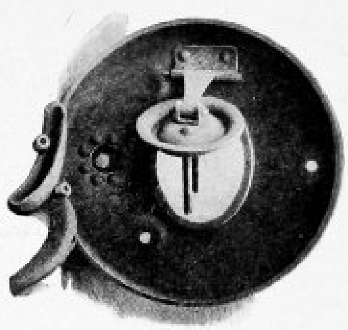
The Lunkenheimer Company, Cincinnati, Ohio, are manufacturing an improved form of blow-off valve designed to avoid any leakage caused by the accumulation of scale or sediment on the valve seat. In this valve it is claimed that any accumulation of scale or sediment which might remain on the seat before the disc is brought into contact with it is washed off by the water which passes around the plug seating. In the sectional view shown herewith it will be seen that the plug *C* carries a reversible double-faced disc *D*, secured to the plug *C*. This plug *C* is guided in the valve body *A*. The bronze seat ring *E* is screwed into a second brass ring *F*, the object being



to make it possible to renew *E* easily in case it is worn. At the back of the valve is the plug *B*, which permits the introduction of a rod to clean out the blow-out pipe when desirable. The screw *N* which raises and lowers the disc *C* is held in place by a lock-nut *L*, which is prevented from unscrewing by a non-rotating washer *K*. When in operation, as the edge of the disc *D* approaches the cylindrical extension *E*, these edges shear and cut off any scale or sediment which might pass. As the disc *D* continues to approach the seat bearing *E* it is claimed that the leakage of water from same will effectually wash out any scale or sediment which might have accumulated thereon, the result being that when the disc is finally seated no scale or sediment is left between the bearings.

A Swinging Manhead Support.

Manhole covers weigh from 50 to 150 pounds and are very unwieldly and hard to handle. When such a cover is fitted with the attachment shown in the accompanying illustration it is only necessary to remove the nuts and yokes from the bolts and swing the manhead away from the opening. This requires

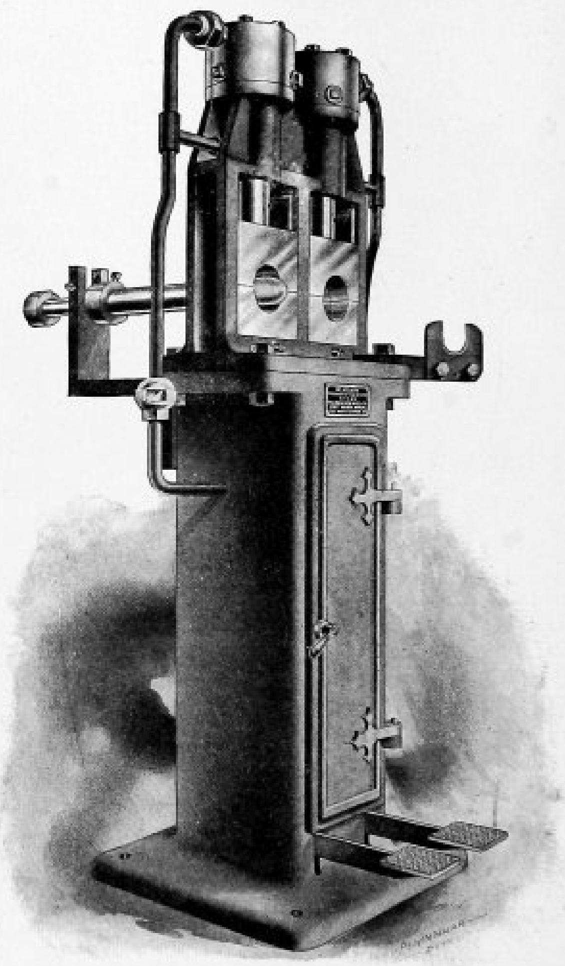


very little work, and subjects the man who is inspecting the boiler to no bodily strain or danger from scalding. By means of this support, the manhead will be brought back in the same relative position with the manhole that it originally occupied, thus always insuring a tight joint. Unless the manhead is supported in some such manner, it will be difficult to bring it back in the same position, and there is a possibility of constant leakage at the joint on this account, which is a source of danger in any boiler.

This attachment may be used on any boiler already in use without securing new manhead plates. It consists of but three pieces, with the necessary bolts, and is easily attached to any style of manhead or boiler by using three standard machine bolts. It is manufactured by the Cahall Steel Specialty Company, Chicago, Ill.

Pneumatic Flue Welder and Swedger.

The Draper Manufacturing Company, Port Huron, Mich., manufacture a pneumatic flue welder and swedger of the double cylinder type which is especially adapted for railroad work where flues are swedged at the end for copper ferrules.



The machine herewith illustrated is capable of handling flues up to 4½ inches in diameter. It is claimed that a 2-inch flue can be welded and swedged in about five seconds with one heat, giving a smooth weld both inside and out, and leaving the flue an even thickness.

Any length of stiff end can be welded on by having a long mandrel and placing the machine directly behind the furnace, allowing the end of the flue to project through the dies while heating, and when hot shoving forward until the weld comes under the dies.

Automatic Injectors.

Injectors for boiler feed may be divided into two classes: First, single tube open overflow injectors; second, double tube positively closed overflow injectors. Fig. 1 shows an injector of the latter class, known as the Garfield double jet injector, manufactured by the Ohio Injector Company, Wadsworth, Ohio. Some of the advantages claimed for the double tube type are that it will work under a wider range of steam pressure; will give more satisfactory results when taking water

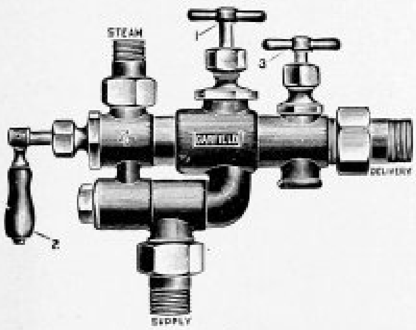


FIG. 1.

from a long lift; will work hotter water, and will deliver the water at a higher temperature than machines of the single tube class; also it is self-adjusting, that is, it requires no regulation of the water supply for varying steam pressures. Only valves of the simplest construction which are positively operated have been used in this injector, in order to insure ease of

FIG. 2.

repair and small cost of maintenance. When it is necessary to clean or repair any of the parts, they may be removed while steam is on the boiler without breaking any tight joints or removing the machine from its connection.

A type of single tube injector, also manufactured by the Ohio Injector Company, is shown in Fig. 2. This is known as the Chicago automatic injector, and it comprises the same features of simplicity and ease in maintenance which are found in the Garfield injector.

Laclede Fire Brick.

Fig. 1 shows a fire brick especially recommended by its manufacturers for boiler settings. This is known as the La-

FIG. 1.

clede St. Louis No. 1, and is manufactured by the Laclede Fire Brick Manufacturing Company, St. Louis, Mo. This brick is made by a semi-dry and stiff mud process, and from the best fire clays obtainable, the approximate analysis of which is as follows:

Silica	57.15
Alumina	27.89
Sesquioxide of iron	1.99
Alkalies	.68
Lime	.66
Titanium oxide	1.07
Combined water	10.54

It is claimed that this brick is very uniform in size, and will stand temperatures up to 3,000 degrees Fahrenheit. The Laclede Company manufacture different grades of brick for all

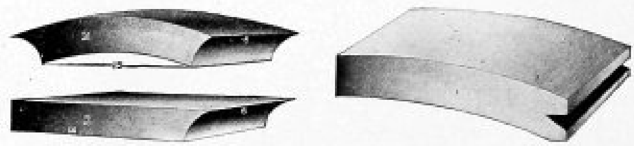
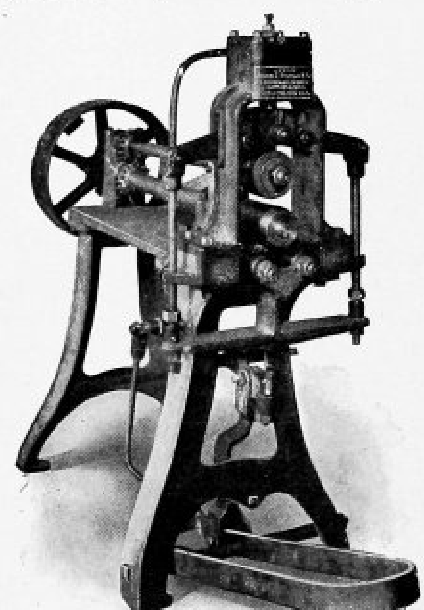


FIG. 2.

the different uses for which such a product is used, and in a great number of different shapes, according to their special uses. Fig. 2 shows three of these special shapes, including a locomotive arch tile and a center side boiler tile.

The Ferguson Flue Welding Machine.

In the Ferguson flue welding machine, which is placed on the market by Joseph T. Ryerson & Son, Chicago, Ill., the tube on which the safe end is being welded is revolved rapidly between rollers. The rollers are so placed as to bear on three points of the circumference of the tube at the same time. One of the three rollers, which is larger in diameter than the other two, is located directly above the tube. This is driven by power. There is also an inner mandrel which has a rotary wiping action on the weld, which is driven by power. A small

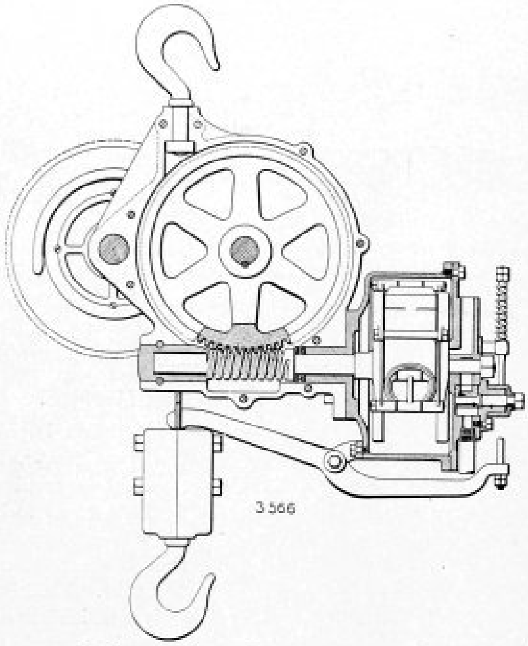


air or steam cylinder just above the upper roller brings pressure on the tube while it is being welded; at the same time the lower rollers are automatically brought up and closed in on the periphery of the tube keeping the gage perfect. A valve connected to a foot lever admits air or steam to the cylinder, all of the other functions being performed automatically. The Ferguson machine may be used with either a coke or oil furnace, and by placing a cutter disc on the end of the upper roller it may be used for cutting off or trimming flues.

The Imperial Air Motor Hoist.

The Imperial Air Motor Hoist here shown, unlike all direct-acting air hoists, does not require a great height above the lift. Perfect control is claimed both for hoisting and lowering, so that the load is absolutely held at any desired point. There is no waste of air in filling long cylinders, the amount used at any time being only that required for the actual work.

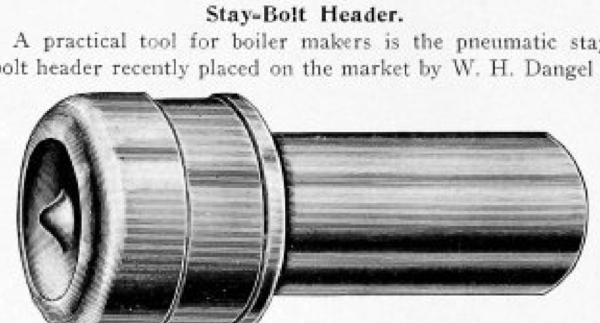
The motor is a positive action reversible air engine with no dead centers and a practically uniform torque. It has no delicate valve mechanism which is liable to get out of order and require



adjustment. It is wholly enclosed, dust proof, splash oiling, with every bearing bushed and bathed in oil. The steel worm on the motor shaft runs in an oil pocket, its thrust being taken by a roller bearing, and meshes into a worm wheel of bronze, a pinion on the worm wheel shaft engaging the drum shaft gear. On the larger sizes of hoist there is an additional speed reduction; on all sizes the friction is minimized by the juxtaposition of the most suitable materials and the precise workmanship and finish of all working parts. The hoisting rope under-runs a groove which always permits an exact equalization of the two sides on the drum. The hook turns on ball bearings, so that the load may be turned in any direction without twisting the ropes and without its turning back. The hoist is made by the Ingersoll-Rand Company, 11 Broadway, New York City, in five sizes, with capacities ranging from 1,000 to 10,000 pounds, using the ordinary air pressures.

Stay-Bolt Header.

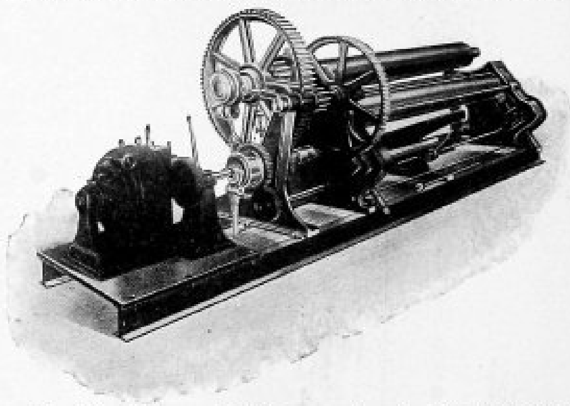
A practical tool for boiler makers is the pneumatic stay-bolt header recently placed on the market by W. H. Dangel &



Co., of Chicago. This tool fits into a pneumatic riveting hammer, the same as a rivet set, and is used to upset and finish the heads of stay-bolts in fire-box boilers. It is already in use in many of the large railroad shops and is claimed to be a great labor saver, as the center point of the tool holds it to the bolt and prevents wobbling. It is made of high-grade tool steel and carefully tempered. In shops where the pneumatic hammer is used for riveting, calking, beading, chipping, expanding and nearly every operation in boiler work, this tool should be welcomed, as it makes possible a quick, neat job on the heads of stay-bolts.

The Bertsch Improved Bending Rolls.

A noteworthy feature about the Bertsch bending rolls is the automatic opening and closing device for opening the rolls to remove the formed metal. The machine is opened by turning down the hinged support for the outer end of the top roll. A cam or lug on the bottom of the hinge lifts one end of a lever, the opposite end of which is connected beyond the fulcrum with the inner end of the top roll, which is thereby pulled down

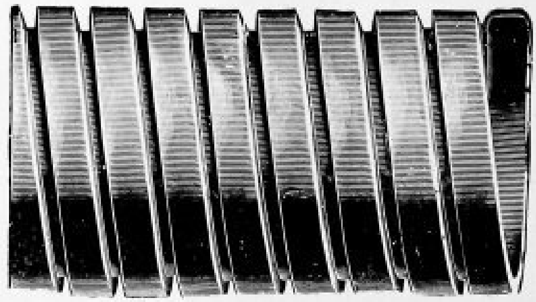


when the hinged support is thrown outward. The bottom rolls are so placed that their weight assists in this motion and gives the whole device a very good balance, so that the top roll may be lifted with very little work.

The roll has a positive feed, and, as the top roll is smaller than the bottom ones, small circles can be formed. The rolls are made of either forged iron or forged steel; the housings or frames being heavy and rigid with wide bearings for the journal boxes. The pinions are made of cast steel and the gears are heavy with wide faces. When driven by a motor or engine direct, the machine is built with an I-beam base plate. This machine is manufactured by Bertsch & Company, Cambridge City, Ind.

Nyflexmet Hose.

Nyflexmet hose is a flexible, metallic hose built up of spirally twisted strips of steel or copper, having their edges turned into interlocking lips, the joints of which are packed with a waterproofed asbestos yarn. The interlocking lip is so turned that the packing cannot work out of the joint, and yet perfect pliability is preserved. The cut shows the spiral character of the

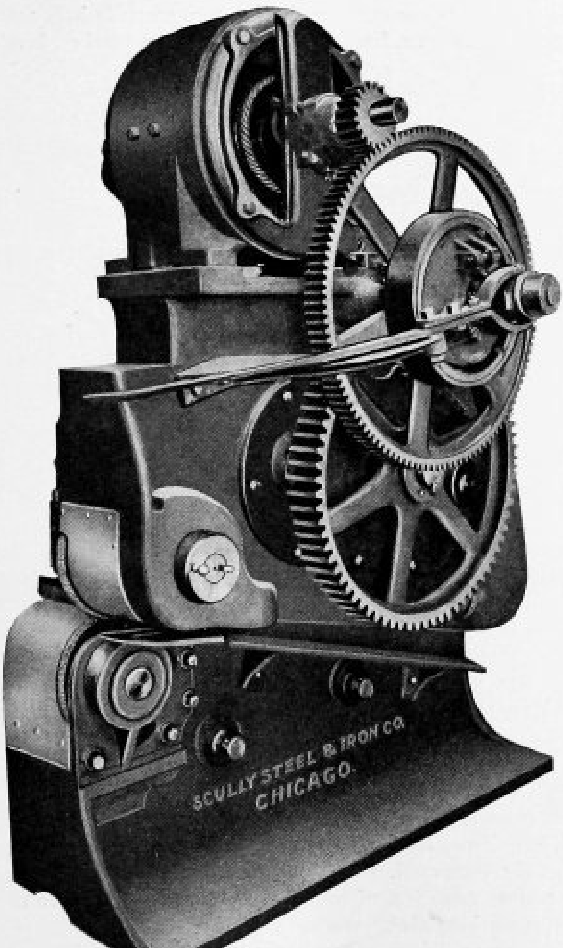


hose and a great variety of special couplings and fittings have been designed for attachment to it. The lightest construction of this flexible hose will stand a pressure of 500 pounds per square inch without bursting, and it is manufactured in all sizes from ⅛ inch internal diameter up to 10 inches, covering a numerous range of applications where flexible connections between rigid or flexible pipe lines for high pressures are required.

A very extensive use for flexible hose of this character has been found in boiler rooms, largely as a steam hose to blow the soot and dust out of flues. For this purpose the New York Flexible Metallic Hose & Tubing Company, 161 Lafayette street, New York, who are the manufacturers of the Nyflexmet hose, have placed on the market the Nyflexmet tube blower, which works on the injector principle. It consists of a nozzle containing a steam jet and a large opening for air and gases which are drawn into the tube by the steam jet. It is claimed that the hot gases thus drawn in decrease the condensation of the steam in the tubes which obviates the tendency toward the formation of a cakey coating on the surface of the tubes.

The Scully Rotary Splitting Shears.

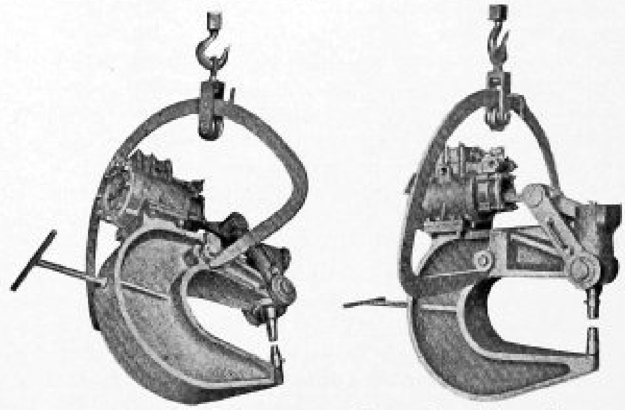
The Scully rotary splitting shears are designed for cutting any thickness of plate up to ¾-inch. As the size of the cut is not limited by the reach or gap of the machine any length or width of plate may be taken without using an excessive



amount of floor space. The cutting is done by means of two hardened tool steel cutters 15 inches in diameter and 1 3/8 inches thick. These cutters have milled edges, so that they feed the material which is being cut through the machine. The cutter hubs run loose on an eccentric shaft, so that the distance between the cutters may be adjusted for shearing different thicknesses of metal. The proper distance between the cutters is approximately one-third the thickness of the metal. The Scully Steel & Iron Company, of Chicago, Ill., have placed this machine on the market.

A Patent Universal Bail.

The Universal bail shown in the following illustrations was designed especially for compression riveting machines, where it is necessary to throw the machine quickly into various positions and still have it remain stable. This requirement is met by hanging the machine so that the center of gravity is always vertically under the point of support, no matter what position the machine may occupy. In order to accomplish this the machine must first be hung in several positions in order to



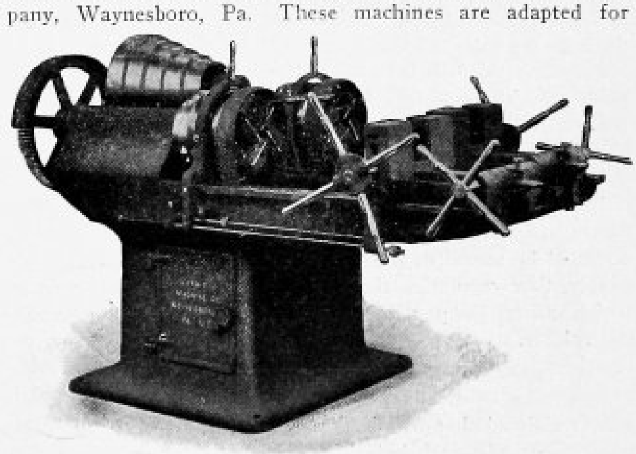
accurately determine the center of gravity. Then by constructing a support in the form of the arc of a circle around this center of gravity it will be seen that the conditions are fulfilled, provided the arc is made large enough so that the machine will turn through the bail itself.

This device practically allows rivets to be reached at any angle while the machine is still kept in the most convenient position for handling. The supporting wheel runs easily on the bail, and a man with little effort can quickly throw the machine into the desired position. A small pinch pin, the handle of which can be seen in the illustrations, serves, by means of a half turn, to lock the wheel to the bail, thus preventing any possibility of the machine shifting during the operation of riveting.

This Universal bail patent is the property of the Chester B. Albree Iron Works Company, Allegheny, Pa., and the device is widely used on the many different styles of riveters manufactured by this company.

The Landis Bolt Cutter.

The accompanying illustration shows a 2-inch double head Landis bolt cutter, manufactured by the Landis Machine Company, Waynesboro, Pa. These machines are adapted for



cutting right or left hand threads on any sized bolt within their rated capacity. The beds are of heavy design, cast in one piece, with oil and chip pans located inside.

The carriage is of an improved form, and the vise has guides centralized over the work which is being cut with a clamping screw immediately below in order to eliminate side thrust. The rack is in the center of the machine immediately below the bolt which is being held. The die is composed of four chasers made from flat pieces of steel with heads milled the entire length of their flat side. The throat is formed by beveling the front edge of the chasers, giving a permanently uniform shape. A lead screw is unnecessary, as the die forms a lead nut in itself. The front teeth of the chasers do all the cutting, while the back teeth do no cutting at all, but take bearing on the work a little back of the face of the chasers, and thus form a permanent hardened lead nut whose bearing service is renewed each time the chaser is reground. Since the simple grinding operations renew the die, all annealing, hobbing and retempering is practically eliminated.

Compressed Air For Blast.

The wide use of compressed air for blast in forges in boiler shops by merely making compressed air connection to the "wind box" of the forge and regulating the blast by a globe valve causes a, perhaps unnoticed, lack of economy in power, for all the air supplied to the fire must pass through the compressor. On this page is shown a machine recently placed on the market by the Buffalo Forge Company, of Buffalo, N. Y.,

in which only a small percentage of the air passing to the fire is taken from the compressed air system, thereby lessening the loss of power from this source. A tiny jet of air regulated by a needle valve impinges on the blades of a centrifugal fan, thus causing the wheel to rotate at a high speed. Due to centrifugal action causing suction, the fan draws in free air through the inlet opening equal to forty times the volume of compressed air used. The velocity of the air leaving the fan blade tips causes an accumulation of pressure in the wind box beneath the tuyere, through which the air passes to the fire. The tuyere is of special design—the air passing through slots in a sphere of cast iron about 3 inches in diameter. A twist on a handle provided will revolve this sphere, breaking off any clinker which may have formed. Blast regulation is obtained by means of the needle valve on the compressed air supply, thus regulating the speed of the fan. This is a forge which utilizes the power in the compressed air and not merely the volume.

Falls Hollow Stay-bolts.

It is claimed that sufficient oxygen is admitted through the small ⅛ or 3/16-inch hole in all the hollow stay-bolts necessary to equip a modern high-pressure locomotive boiler to carry out almost perfect combustion of the fuel. Also the current of air passing through the hollow bolt reduces its temperature, thereby preventing undue expansion and contraction. The air thus acts as a protection against the burning of the inner ends of the stays and the cracking of the side sheets. Hollow stay-bolts are superior to solid stays with tell-tale holes, in that a break at any point in the bolt will be immediately detected as a current of air through the bolt keeps the hole from clogging up.

The Falls Hollow Staybolt Company, Cuyahoga Falls, Ohio, manufacture both hollow and solid stay-bolt iron of the same high grade, double refined charcoal iron, which is a blend of imported Swedish and native high grade charcoal iron stock. This grade of stay-bolt iron has proved its usefulness by its wide use on many different railroads.

The Hauck Burner.

A portable burner which gives a very powerful flame is being manufactured by the Oil Fuel Engine Company, 225 South street, New York City. The entire weight of the outfit is about 100 pounds. Pressures varying from 15 to 100 pounds per square inch may be used in the tank, while the flow of oil to the burner is controlled by means of valves. In this way the operator can get a flame of the proper intensity for the particular piece of work at hand.

This device is especially useful for such work in boiler shops as flanging, turning, bending plates, laying on patches, bending

pipes, etc. It is also used for bridge and structural iron work; for annealing frame plates, for bending, straightening and welding on board ships, for heating cranks when necessary to remove the crank pins, and all other similar repair work. Some of the claims which are made for it include instantaneous lighting, complete combustion, ease of control, economy of fuel and reliability.

The New Franklin Air Compressor.

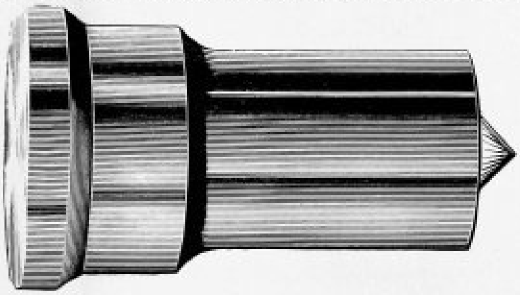
The Chicago Pneumatic Tool Company, of Chicago, Ill., is manufacturing air compressors of the duplex pattern with simple or cross compound steam cylinders and simple or two-stage air compressing cylinders in sizes ranging in capacity from 30 to 2,000 feet of free air per minute, or from 10 to 125 pounds working air pressure.

The steam driven compressors are provided with a compressor regulating governor to automatically control the operation of the compressor in accordance with the demand for air, working in connection with a speed governor which regulates the speed of the compressor. The steam valves on the small sized compressors are plain *D* slide valves, but on cylinders 12 inches in diameter and over Meyer adjustable cut-off valves are provided, the main valve being balanced. The air inlet valves are of the poppet type with removable seats and guides. The larger sized compressors are provided with valves of the semi-rotary Corliss type driven from eccentrics on the main shaft. All of the air discharge valves are of the poppet type.

The intercooler provided with two-stage compressors forms part of the compressor's base directly under the air cylinders. The intercooler tubes are brass or charcoal iron expanded in steel tube sheets. Baffle plates are inserted between the tubes to insure a complete circulation of both water and air.

New Process Punches.

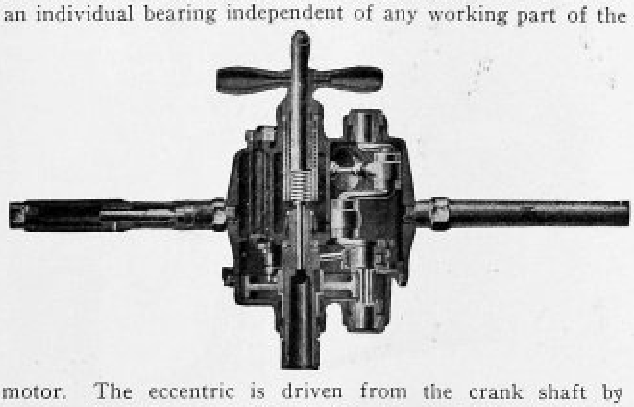
The punches manufactured by George F. Marchant, Lake and Elizabeth streets, Chicago, Ill., are tempered by a secret process which is claimed to make the punches very durable. In shipping each punch is packed separately in a cardboard



box in order to prevent the abrasion of the cutting edge, thus each tool when received by the manufacturer is in perfect condition and its life materially lengthened. All machinery used in the manufacture of these tools is especially designed for the purpose and built on the premises.

The Thor Pneumatic Drill.

The motive power of the non-reversible drill shown below is compressed air, which is used in four single-acting cylinders placed in the body of the drill. The admission of air to the cylinders is controlled by means of Corliss valves, the valves being immediately adjacent to the cylinders. The valves are operated from one double eccentric, which is provided with an individual bearing independent of any working part of the



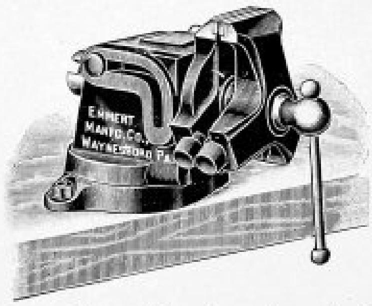
motor. The eccentric is driven from the crank shaft by means of a spur gear. The feed is telescopic, thus giving a feed practically double that which could be obtained with an ordinary single feed rod.

The case of the motor is made with but one joint. The cylinder and gear case are made of steel castings. All wearing parts are either steel forgings or are turned from solid steel stock.

The Independent Pneumatic Tool Company, of Chicago, who make the drill just described, also manufacture a reversible drill which has the same general features as the non-reversible, with the exception of a device for admitting air to the cylinders so as to cause the drill to rotate in the opposite direction. This is done by sending the air through the exhaust port into the valve chamber and thence into the cylinders by means of a simple two-way valve which is placed in the admission chamber at the inner edge of the inlet pipe.

A Universal Vise.

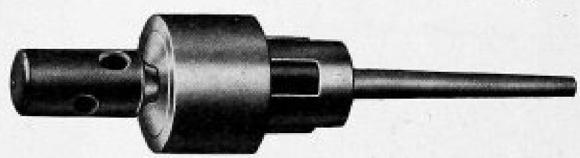
The universal vise shown below does not differ materially in its action from a common screw parallel vise, but it may be thrown into any desired position while still holding the piece of metal on which work is in progress, so that the work is brought into the most convenient position. The vise is provided with five pairs of holding jaws; one for filing and fitting, one for round or finished work, one for rings, segments, hollow parts, or irregular shapes, one for tapers, either round or



square, and for smaller metal rods, and one for holding pipe, large cylinders, etc. Three of these jaws are shaped on the vise head, any pair of which may be brought into service singly or together in pairs; thus when using a 3-inch jaw for metal work it is just as easy to have the service of a 6 or 7-inch jaw by placing the article to be held between two pairs of jaws turned to the position sought, allowing the article to rest on the vise beam between the jaws. This, of course, permits the work to be held more firmly. The grip and nut in this vise are combined and are very strongly constructed of semi-steel, tempered and bolted to the inner jaw of the vise, so that they may be revolved together with the entire vise head and jaws by simply slightly releasing the positive grip tension on the article which is being held. This vise is manufactured by the Emmert Manufacturing Company, Waynesboro, Pa.

The Faessler Universal Roller Flue Expander.

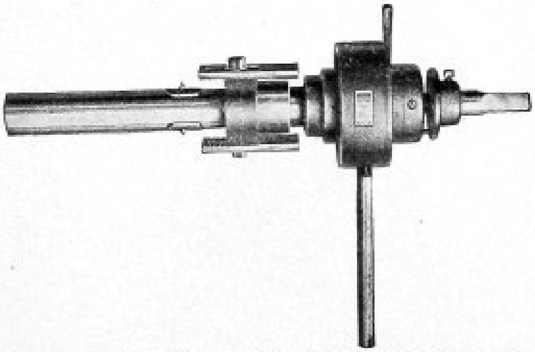
The type of expander shown in the illustration is so constructed as to roll flues which are cut off longer than necessary, as is often the case. By reversing the collar on the cage the expander will roll flues which are ½ inch too long, or by



removing the collar entirely it will roll a flue which is 1¾ inches too long. The rollers in this expander are double the necessary length and are reversing. The illustration shows a tool for hand use only, but the same type of tool is made for use with an air motor. The expander consists of only six parts, namely, a tapered mandrel, three rollers, a cage for holding the rollers in place, and a collar. It is manufactured by the J. Faessler Manufacturing Company, Moberly, Mo.

The O'Neill Rapid Tube Cutter.

The O'Neill rapid tube cutters, manufactured by Christopher Murphy & Company, First National Bank building, Chicago, Ill., may be used not only for removing old tubes from boilers but also for trimming new tubes outside the head. To change to either operation it is only necessary to reverse the guide which rests against the boiler head, which takes only a few seconds. This tool operates on the combined principle of the roller pipe cutter and the inside causing cutter. It has two knife carriages, diametrically opposed to each other, upon each of which is mounted a wheel knife having an A-shaped edge. The carriages are forced outward against the inside of the flue or tube by means of a wedge-shaped spindle, which in turn is fed by a screw thread, making the control absolute and the feed positive. As soon as the tube is cut the cutters cut out automatically. Dogs of an improved pattern engage the spindle,



thus preventing the possibility of stripping the thread on the spindle. Both the carriage and spindle are machine fitted and grooved in order to insure perfect alinement.

All parts coming in contact with the work are of hardened steel. The steel cutters run on hardened bearings and are easily and cheaply removed. Since the machine is furnished with ball bearings little power is required, and it may be operated by hand with a common wrench or with an air motor.

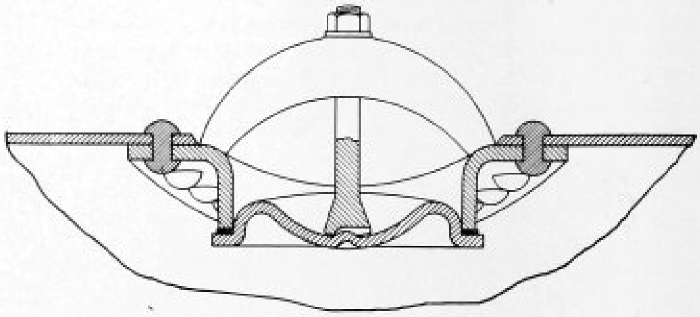
Rockwell Rivet Heating Furnace.

The rivet heating furnace shown herewith is made in two general sizes, each of which has a height of 56 inches. The smaller size has a heating chamber measuring 10 by 15 inches, and the larger size two heating chambers identical in size to

that in the smaller one. The furnaces may be used with either oil or gas fuel, and will heat rivets up to 1½ inches in diameter rapidly. The large size furnace consumes from 2 to 3 gallons of oil, or from 200 to 350 cubic feet of gas per hour, and it is especially useful for heating a variety of sizes of rivets or for supplying more than one gang at the same time. The Rockwell Engineering Company, 26 Cortlandt street, New York City, are the manufacturers.

The Roe Manhead and Yoke.

The Roe manheads and yokes are made from the best open hearth steel plate in the form of a true ellipse. It will be seen from the illustration that the metal is disposed in a series of corrugations, the central corrugation forming a dovetail which grasps the bolt, at the same time giving the bolt sufficient freedom for alinement without producing undue strain on the manhead. The edge of the manhead is flanged down and then out in order to form a joint surface.



The yoke is made with either a flat base for general use or with a concave base where an installation similar to the one shown in the sectional cut is necessary. The latter method makes it unnecessary to countersink the rivets for the yoke saddle, and, therefore, makes a stronger frame.

The manheads, yokes and saddle are manufactured by the Glasgow Iron Company, Pottstown, Pa.

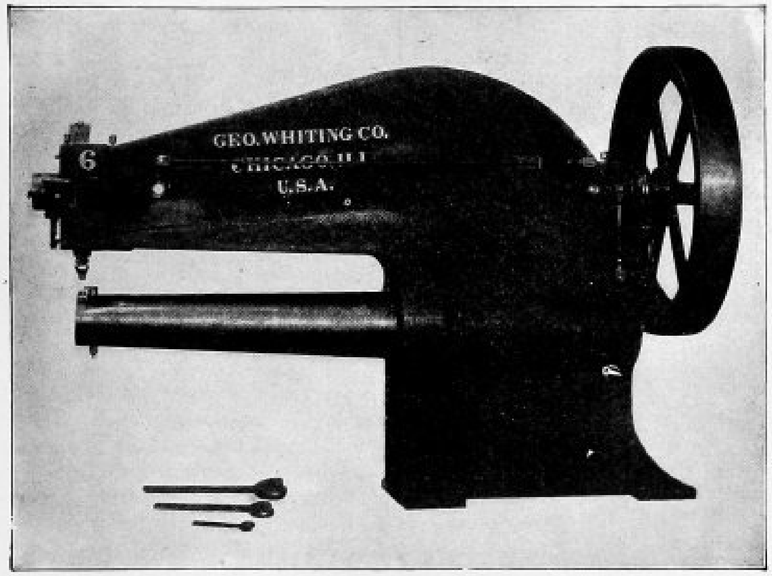
The Buckeye Heater.

The Buckeye heater is practically a large blow-pipe, giving a powerful flame of about 2,500 degrees F., which can be adjusted to the exact spot requiring heat. For this reason it is specially valuable for heating crown sheets, sagged ends, laying on patches or laying up laps at corners and joints and

also for flanging. The heater is manufactured by Walter Macleod & Company, 213 East Pearl street, Cincinnati, Ohio, in two different types. The first type is a complete portable machine, generating its own gas, vapor and air. The burner in this case requires heating before the generation of gas can take place. The second type, which is shown herewith, is dependent on a supply of compressed air, but has the advantage that it can be turned on or off instantly, and also by varying the oil and air supply a flame of varying intensity can be obtained.

The Whiting Quick Acting Belt Power Riveter and Punch.

The cut herewith shown represents a combined riveter and punch, designed and manufactured by the George Whiting Company, 160 W. North avenue, Chicago, Ill., to reduce the cost on punching and riveting such work as smoke stacks, water pipe and similar cylindrical work. The particular machine illustrated has a stake 50 inches long and a capacity for driving ⅜-inch cold rivets or punching ½-inch holes in ⅜-inch steel, although it may be made in different capacities with stakes of different lengths. It is so arranged that holes can be punched very close to the edge of a plate. It is also designed to drive cold rivets with a single blow. Instead of the old method of punching up two ends of a sheet and then rolling

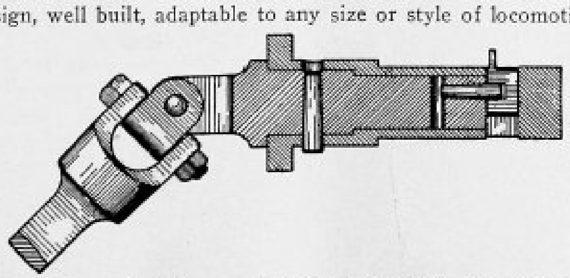


them together and afterward riveting them, it is claimed that with the Whiting combined riveter and punch it is possible to roll the sheets and punch through the two courses at one operation.

The machine is fitted with a special arrangement, by means of which the rivets can be put in from the top or outside of the work, thus performing the work much quicker than by the old method of putting the rivets in from underneath. The machine is of the quick acting type, operated by belt power and runs 90 to 100 strokes per minute. It can be changed from a punch to a riveter, or vice versa, in a few minutes.

The Redington American Flue Cutter.

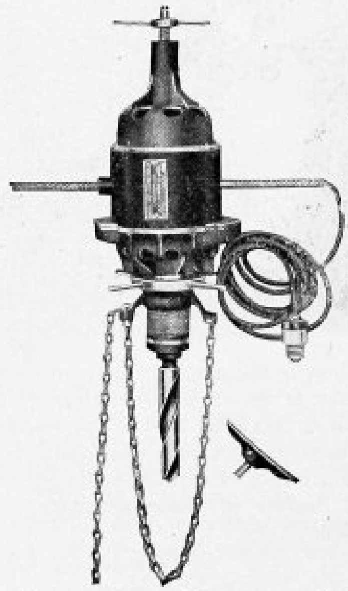
The Redington American flue cutter was invented and perfected in a railroad shop, where it had been in use for more than a year before it was put on the market. It is simple in design, well built, adaptable to any size or style of locomotive



and can be used with any make of air motor. The unusual feature claimed for this tool is that it can cut out a boiler flue in a single revolution. A sectional view shows the swivel joint by which the tool is operated and the cutting knife. As soon as the motor is started the knife is thrown out in a radial direction and cuts the flue off in a single revolution. This device, which has been in operation for over five years on a number of large railways, is manufactured by F. B. Redington Company, Monroe and Sangamon streets, Chicago, Ill.

A Portable Electric Drill.

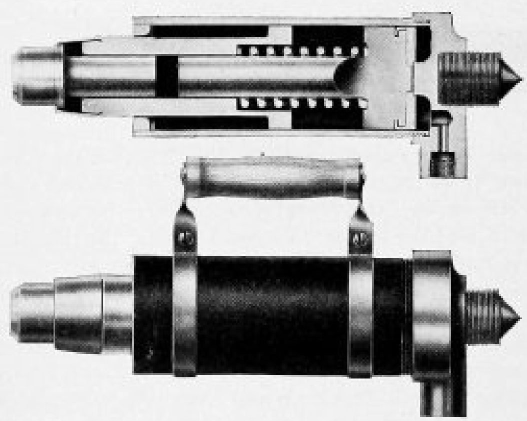
The tool shown below, manufactured by the United States Electrical Tool Company, of Cincinnati, Ohio, is exceedingly compact and light, considering the work it has to do. The prime necessity in the construction of portable electric tools of all kinds is to reduce the weight as much as possible, at the same time keeping the power sufficient for the rated capacity, or, in other words, the tool must not be over-rated. The tool shown is a 1¼-inch electric drill and is capable of



drilling holes up to the size mentioned in iron or steel. It is especially adapted to use in boiler shops, especially where it is necessary to take such tools out on repair jobs. The power is obtained from an ordinary electric lamp socket. This tool may be furnished with or without a chain-feed attachment.

A Pneumatic Holder-On.

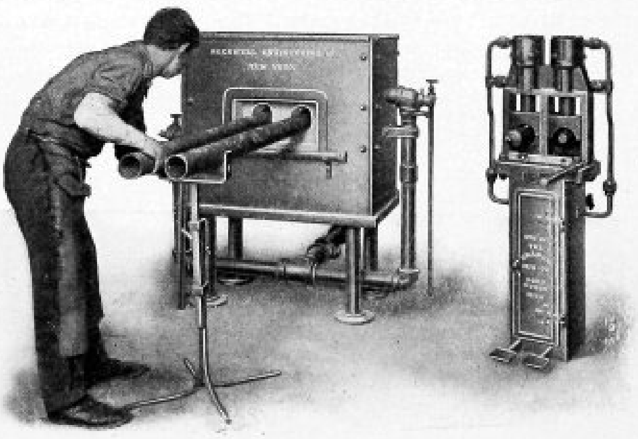
The construction of the pneumatic holder-on herewith illustrated is clearly shown in the sectional cut below. Mounted upon the regular air piston is a rider piston, so that for each



blow struck by the pneumatic hammer on the rivet there is a corresponding reacting blow given by the rider piston upon the rivet head. It is claimed that this reactive blow lays up the head of the rivet and performs the same office as a calking tool, so that when used in boiler work there is much less liability of leaking around the rivets, even though they are not calked. No more air is required to operate this holder-on than in a tool of the ordinary kind. It is manufactued by the Gunnell Machine Company, Manitowoc, Wis.

Rockwell Flue Welding Furnace.

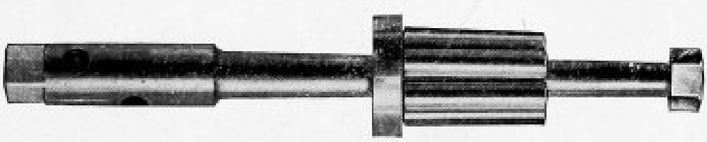
The Rockwell Engineering Company, 26 Cortlandt street, New York City, has on the market a flue welding furnace in which the fuel is either oil or gas. This furnace will take flues up to 4 inches in diameter, heating the larger sizes to a weld-



ing heat in about 1½ minutes. Two flues may be kept in the furnace at the same time, and under full heat about 7 gallons of oil or 700 cubic feet of gas are consumed per hour. The furnaces occupy only a small floor space, 20 by 38 inches, and have a height of 50 inches. This furnace is designed to heat flues rapidly in connection with modern quick-acting flue welders.

The Nicholson Boiler Tube Expander.

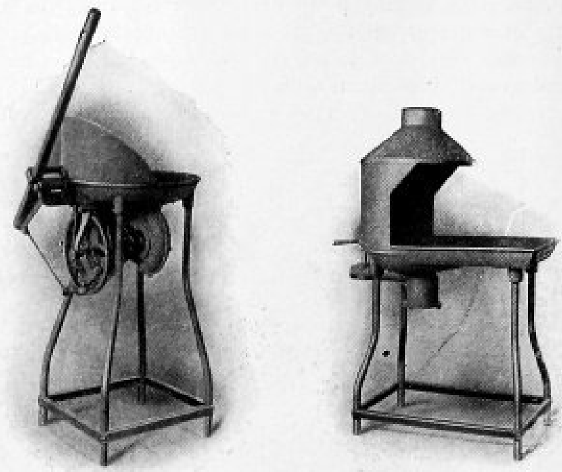
The Nicholson roller tube, self-feeding expander, manufactured by W. H. Nicholson & Company, Wilkesbarre, Pa., is designed to be operated either by an air motor or by hand. The tool is composed of only nine separate parts, namely, a tapered mandrel, six rollers, a retaining collar and nut. The heads of the rollers are spherical and fit into spherical bearings in the retaining collar, thus forming a ball and socket joint, which permits the rollers to work freely at an angle in either direction, thus making it possible to roll the tubes by turning



the mandrel in either direction. The fact that the rollers are thrown at an angle when the mandrel is revolved makes the tool self-feeding, and, therefore, it requires no hammering or force to feed the tool into the work. After the tube is rolled, a few turns of the mandrel in the opposite direction immediately releases the expander. All parts are made from the best tool steel and are hardened throughout. It is claimed that the fact that six rollers are used insures a much tighter, quicker and smoother job than it is possible to obtain with an ordinary expander, and also that it may be done with less power.

The Sturtevant Forges.

The simplest style in the lever type of the portable forges manufactured by the B. F. Sturtevant Company, Hyde Park, Mass., is illustrated herewith. These forges, equipped with hand-operated blowers, are adaptable to all light work such as ordinary forging, heating plates, rivets, etc. The pan is of heavy cast iron, provided, as shown in one illustration, with a visor or wind guard, and as in the other with an open-front hood with pipe connection. A hardwood handle starts the running gear easily and positively. The gear teeth are accurately shaped, the shaft bearings are large and an adjustment is provided for always keeping the gears in mesh. The

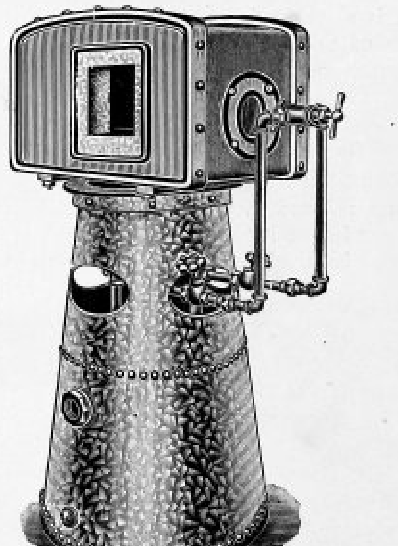


fan-wheel is in one piece, the shaft running in babitted bearings. The tuyere is free and open and an air-tight outlet provides for ready cleaning. The fire-plate is heavily ribbed to prevent cracking, and is insulated from the pan and running gear by means of asbestos.

The stationary types range in size from 26 by 30 inches up to the largest steel plate style measuring 6 feet square.

Buckeye Oil Rivet Forges.

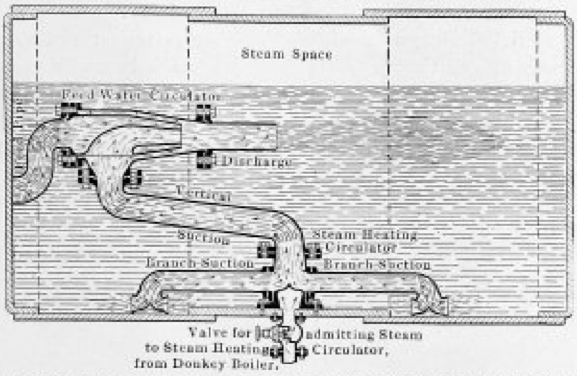
In order that rivets may be heated rapidly enough to keep pace with modern power riveters, oil forges have come into use to displace the older types of soft coal forges. The oil rivet forge, shown below, which is manufactured by Walter Mac-



leod & Company, 213 East Pearl street, Cincinnati, Ohio, is arranged to heat rivets progressively; that is, as soon as a rivet is removed from the forge another falls by gravity into the hottest part of the furnace to take its place. This forge is strongly built yet easily portable. It requires about 20 cubic feet of gas per hour, or about 1 gallon of oil. Any description of kerosene oil, either crude or refined, may be used as fuel.

An Equilibrium Circulator.

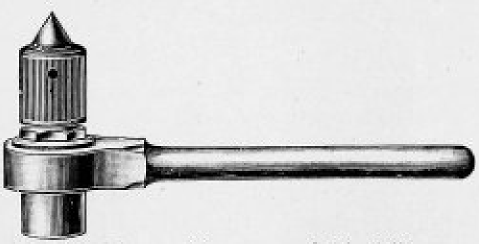
H. Bloomsburg & Company, 425 North Carey street, Baltimore, Md., manufacture a feed-water circulator for use in tubular boilers which is said to greatly aid the circulation and, therefore, the efficiency of the boiler. The circulator consists of a casting located near the surface of the water inside of the boiler and attached to the internal feed pipe at the point marked "feed" in the illustration. From the bottom connection a suction pipe leads to the bottom of the boiler. When the feed-water enters the boiler it passes through this casting,



discharging through the feed-water chamber and annular discharge opening into a short brass discharge nozzle, where its velocity causes an induced current to flow through the internal suction passages up from the bottom of the boiler; thus the colder water is drawn up from the bottom of the boiler, being heated in its passage up through the hot water near the surface, and after mixing with the entering feed-water is discharged near the surface. The hotter water above then must settle to the bottom of the boiler to replace the colder water which is removed, thus keeping up a constant circulation and preventing scale formation or the deposit of solid matter.

Boiler Ratchet Drill.

A ratchet drill is an almost indispensable tool in the boiler shop, since it can be used in many places where a power drill cannot be set up. The accompanying illustration shows a ratchet drill manufactured by the Charles Parker Company,



Meriden, Conn. The working parts of this drill are very simple, being made with a view to durability, and all are encased, and therefore protected from dust and injury. The lever can be worked in a very small space; therefore, adding greatly to the usefulness of the tool. Great care is used in manufacturing the drills to make the parts fit accurately, and the entire surface is highly polished.

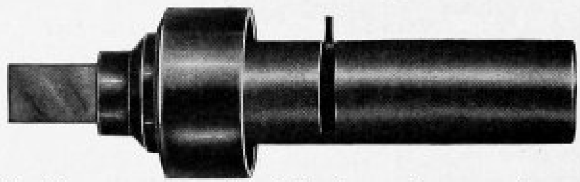
Smooth-On.

Smooth-On elastic cement, which is manufactured by the Smooth-On Manufacturing Company, 53 Harrison avenue, Jersey City, N. J., finds many applications in boiler work, as when it is spread on joints or seams it is said to insure a steam-tight joint without calking. A soft patch, when constructed in the right way and filled with a mixture of Smooth-On cement forms a very durable and strong patch. There is also the advantage that the boiler may be used as soon as the patch is applied. When used between the plates, forming a hard patch, it acts in the same way as when used in seams, making calking unnecessary. It is also useful for filling up the recess where one flanged plate joins another.

A gasket is made by this company for use in packing steam pipe flanges, which is designed to give a tight joint not only while the pipe is hot but when it is cold as well. The gasket is of corrugated iron and, therefore, expands and contracts with the piping. The gasket is coated with Smooth-On cement which, due to its elasticity, also expands and contracts without cracking, and thus a tight joint is obtained for all temperatures.

The Faessler Flue Cutter.

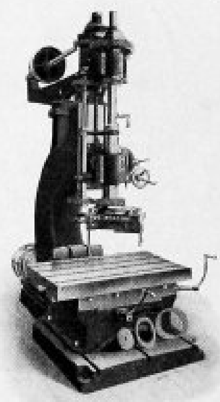
It is claimed that the flue cutter which is manufactured by the J. Faessler Manufacturing Company, Moberly, Mo., will cut a flue off square without leaving any burr. This is an advantage which permits the flue to be taken out from the same hole where it was first put in. The apparatus may be used



with either a common 18-inch hand wrench or an air motor. An apparatus for mounting the cutter and motor is also made which can be attached to a locomotive front end by two studs or bolts. Once the apparatus is in position an entire set of flues can be cut without resetting the apparatus. This is made possible by means of a telescopic shaft with universal joints. With this apparatus the operator does not have to hold the motor.

An Elliptical Boring and Milling Machine.

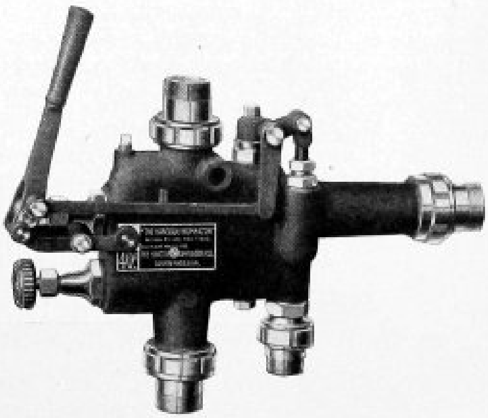
The elliptical boring, turning and milling machine shown below is especially designed for use in boiler shops, shipyards, etc., for turning manheads. By changing the gears, oval, triangular, square and various other irregular shapes can be



turned, or by throwing out an idler the machine will bore round. Thus the machine may be used as an ordinary heavy drill for drilling and tapping, and can easily do the work done by a radial drill. The spindle speed may be varied from 2½ to 90 revolutions per minute, and the down-feed is automatic, belt or gear driven, while the cross feed is star feed. The C. C. Wais Machine Company, Cincinnati, Ohio, are the builders.

The Hancock Inspirator.

The Hancock inspirator is of historical interest as it was one of the first types to be used commercially. The present day type shown herewith does not differ from the original inspirator in principle or general formation. It is, however, controlled by one lever or handle, which makes it very simple to operate. The regulating valve throttles the steam supply to the lifter steam nozzle only, thereby reducing the capacity of the inspirator from the maximum to the minimum without throttling the water supply. It is claimed that this inspirator will lift feed water 25 feet, and that it can be started under



15 pounds steam pressure. It is also claimed that it will work up to 250 pounds steam pressure, and will take feed water at a temperature of 150 degrees Fahrenheit. The general offices of the Hancock Inspirator Company are at 85 Liberty street, New York City.

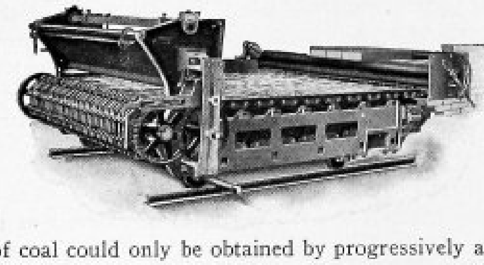
A Patent Self-Feed Roller Tube Expander.

In the tube expander herewith illustrated, which is manufactured by A. L. Henderer's Sons, Wilmington, Del., the rolls are set at an angle with the mandrel and thus have a tendency to draw it into the tube. This, of course, makes it unnecessary to drive the mandrel in with a hammer, for as soon as it is forced against the rolls it immediately takes a hold and gradually feeds its way in, thus insuring a steady, even expansion of the tube. An important im-

proved feature in this expander is the thrust ring which is threaded to the body and may be adjusted to allow tubes to project any required length beyond the tube plate for beading. All wearing parts are hardened to withstand the necessary hard wear to which such tools are subjected, and there are no screws used in the construction to become broken or loose. The expander may be used successfully in connection with pneumatic or other power appliances, since the mandrel can be made to fit any socket.

The Green Portable Link Grate.

The chain grate form of automatic stoker was originated in England in order to carry out the idea that chemical combus-

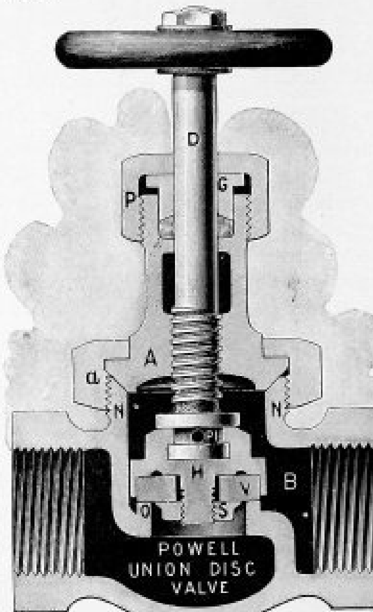


tion of coal could only be obtained by progressively advancing the coal in the furnace so that each component of the coal would be completely consumed on reaching that portion of the furnace which was adapted and designed for its proper combustion. By this means, the operation of feeding the coal into the furnace, carrying it through progressive stages of combustion, removing the ashes and clinkers and maintaining a clean grate surface and free supply of air were to a certain extent automatically performed. The accompanying illustration shows a modern grate of this type manufactured by the Green Engineering Company, Western Union Building, Chicago, Ill.

The Powell Union Disc Valve.

A sectional view of a union disc valve manufactured by the William Powell Company, Cincinnati, Ohio, is herewith shown. These valves are intended only for moderate pressures, such as low-pressure steam or hot-water heating systems.

The bonnet *A* has a crown point where it is held in contact with the body neck *N* by the union nut *a*. This is claimed to eliminate the troubles caused by corrosion and the cementing of this joint.

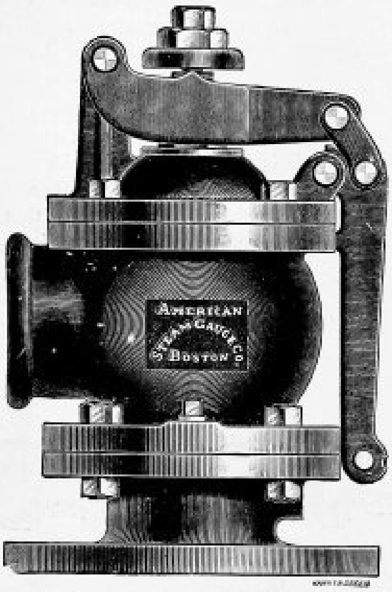


The screw stem *D* has double forcing collars on its lower end which engage the upper and lower bearings of the gear *H*, which holds the composite disc *V*. The upper collar fitting snugly over the top flange of the gear holds it steady from wabbling when the disc is being raised from or lowered upon its seat. The upper stem collar is finished on its upper face to make the steam-tight joint against the lower face of the bonnet hub so that the valve may be packed when the pressure is on and the valve wide open. The accurate seating of the disc when closing is assured by the disc gear *H*, which is held to a true axial position by guide ribs cast in the body shell.

The American Special Pop Safety Valve.

The pop safety valve herewith illustrated is designed for working pressures up to 300 pounds with a test pressure of 450 pounds. The valve casing is made in three parts, the valve bushing or body seat being solid, and expanded into the valve casing at the lower end, thus preventing the seat from rising under pressure. The spindle is fitted with a loose flange having a spherical bearing resting on a projecting collar on the spindle. The lower end of the spring rests on this flange, thus distributing evenly the load of the spring under compression.

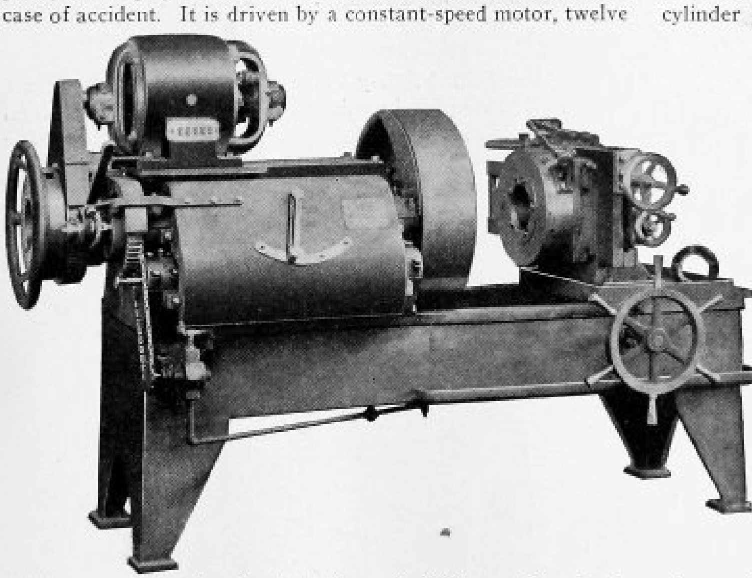
The point of the opening of the valve is governed by the compression of the spring, and is adjustable. The blow-back, or closing point, is controlled by a special adjustable relief ring which determines the amount of opening and gives the lift of the valve under compression. A testing nut for the preven-



tion of injury to the valve spring during testing and a lock-up device are provided with the valve. The American Steam Gauge & Valve Manufacturing Company, 208 Camden Street, Boston, Mass., are the manufacturers.

A Four-Inch Motor-Driven Pipe Machine.

The Stoever Foundry & Manufacturing Company, Myerstown, Pa., has endeavored to design a pipe cutting and threading machine which will be simple in the arrangement of its parts, thoroughly accessible and easily and cheaply repaired in case of accident. It is driven by a constant-speed motor, twelve



different speeds being obtained, four of which are given by the shifting gears in the gear box, and three for each of these feeds by the clutch on the machine. Since the machine is driven by a constant-speed motor it can easily be changed to a belt-drive or, if desired, a variable speed motor, giving a greater number of speeds, can be installed although the expense is greater. The machine is of an exceedingly substantial construction throughout. The head stock is in one casting. All the interior parts are of steel, the three gripping jaws being of tool steel carefully hardened. The rear chuck is of the three-jaw universal type, its function being simply to center the pipe, holding it in line with the die head. The die head is movable to a certain degree, providing for the eccentricity to be found in all pipe. This relieves the great strain which is usually brought on the dies in a rigid head and insures a more equal depth of thread around the circumference of the die. This machine has a capacity for threading or cutting off pipe or stay-tubes from 1 to 4 inches in diameter.

A Rocking and Shaking Grate.

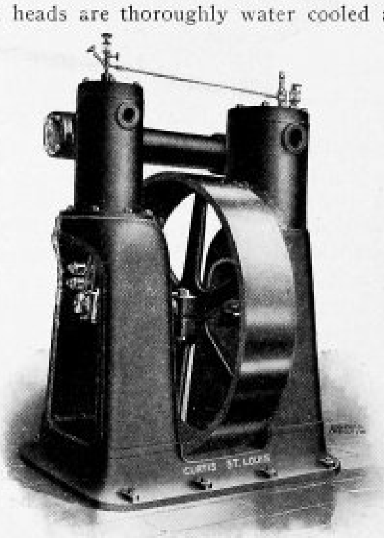
The Martin anti-friction rocking and shaking grate is designed to avoid the serious loss of fuel and steam which occurs with ordinary stationary grates by opening the fire doors to slice the fire. The grate bars may be quickly arranged to suit any grade of coal, and when once adjusted the act of shaking does not change the space between the bars. The grate bars run lengthwise of the furnace and rest on bearing bars in the shape of an inverted dome, which arrangement it is claimed reduces the friction very materially.

The heavier part of the grate bar is 5 inches below the fire line, and is provided with a thorough cross ventilation, so that it cannot become hot enough to warp. A slot at each end of the bar permits of expansion where the bar is hottest. There are no fingers or projections fitted in connection with the grate to project into the fire and be disturbed.

This grate is manufactured by the Martin Grate Company, Fisher Building, Chicago, Ill.

Curtis Automatic Compressor.

The Curtis & Company Manufacturing Company, St. Louis, Mo., have on the market a vertical, single acting, double stage, compound belt driven air compressor with intercooler. The size of the compressor is 15 by 8 by 12 inches and it is adapted to pressures up to 110 pounds. The total weight of the machine is 4,500 pounds, and at a speed of 150 revolutions per minute it has a capacity of 138 cubic feet of air, while at 200 revolutions per minute it has a capacity of 184 cubic feet. All cylinder jackets and heads are thoroughly water cooled and

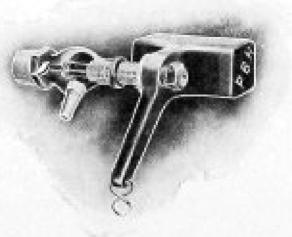


the machine is automatic and self-oiling, requiring practically no attention.

An important feature of the compressor is the intercooler, which is 8 inches in diameter by 3 feet long.

A Weighted Gage Cock.

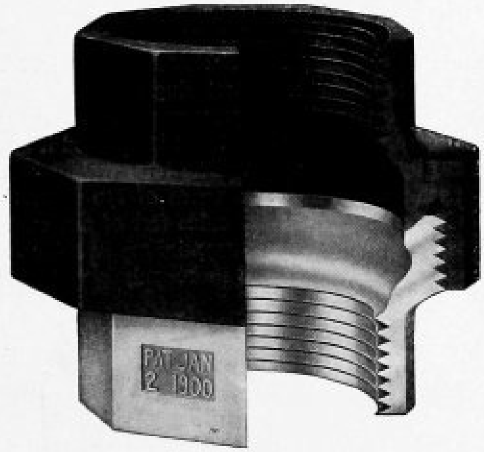
The accompanying illustration shows a quick-opening and self-closing gage cock brought out by the Paul B. Huyette Company, 1500 Betz building, Philadelphia, Pa. Over ½ inch of the valve pencil is available for use, and when completely worn away it can be quickly replaced by a new pencil at a trifling cost, provision being made for ejecting the short piece remaining in the stem by means of the ⅛-inch hole through the stem. It will be noticed that this arrangement for utilizing the valve pencil for over ½ inch in length affords a cock, which, for long periods, needs no repairing or attention



other than occasional adjustment of the weight as the pencil wears away. This adjustment is easily made by unscrewing the nut and slightly raising the weight, which is then screwed in its new position by tightening the nut.

The Octagon Kewanee Union.

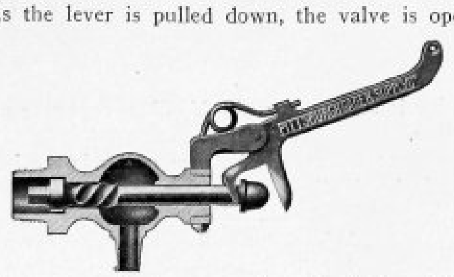
The Western Tube Company, Kewanee, Ill., manufacture a union in which the connection is from brass to iron. It is claimed that this brass to iron thread connection successfully prevents corrosion. A ball joint is provided between the two



ends, and as this is also a brass to iron connection no gasket is necessary to obtain a tight joint. Both the brass and iron ends are octagonal in shape on the outside, so that the joint may be taken apart with an ordinary wrench. Each of these unions is tested with compressed air under water before leaving the factory, in order to insure that there will be no defective joints.

Pittsburg Rotating Gage Cock.

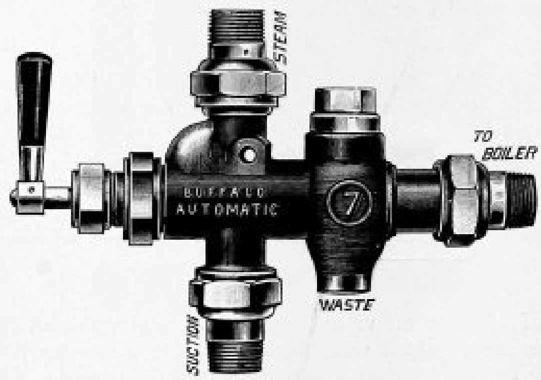
The manner of operation of the Pittsburg rotating gage cock may easily be seen from the sectional view shown herewith. As the lever is pulled down, the valve is opened, al-



lowing steam or water to escape from the boiler. This water passes through a spiral on the stem which rotates the stem rapidly, grinding the seat clean and true and keeping the interior perfectly clear. The spring and claw on the valve stem engage the valve stem keeping the valve tightly closed when there is no pressure back of the seat. On account of the grinding action of the valve, it is claimed that no regrinding is necessary. This gage cock is manufactured by the Pittsburg Gage & Supply Company, Pittsburg, Pa.

Buffalo Automatic Injector.

The automatic injector herewith illustrated is a single-tube injector, for which, it is claimed, that it will work through a wide range of pressures without adjustment, and that it can be easily graded to meet the requirements so that the feed of the boiler may be made constant. Owing to its automatic restarting qualities, it is particularly adapted for portable and



traction engines. The entire operation is controlled by one handle and there are no valves required in either steam or suction pipes. By unscrewing a single nut the whole steam top may be removed so that the interior of the injector may be thoroughly inspected and cleaned. It is designed to work against steam pressures of from 20 to 175 pounds and up, and is easily adjusted. This injector is manufactured by the Sherwood Manufacturing Company, Buffalo, N. Y.

The Consolidated Safety Valve.

The Consolidated Safety Valve Company, 85 Liberty street, New York, have placed on the market the consolidated, nickel seated, base outlet pipe, safety valve herewith illustrated. The

valve has its outlet in the base casting, which permits the removal of the interior parts without disturbing the outlet piping. The valve seats are of nickel, and are beveled to an angle of 45 degrees with the axis of the valve. The spring, which is made of special steel carefully shaped, tempered and tested, is nickel plated to prevent corrosion, and is arranged so that steam will not come in direct contact with it, and the valve is fitted with a Richardson adjustable screw ring, so that the closing pressure may be adjusted from the outside. The working parts are of brass or composition especially adapted to withstand steam of high pressures and temperatures.

A Portable Electric Breast Drill.

The Northern Electrical Manufacturing Company, Madison, Wis., have produced a portable electric breast drill to be operated on a 110 volt direct current circuit. The motor is series wound, and is started with a snap switch located conveniently for the workman. The current consumption is stated to be from 100 to 150 watts. The net weight of the drill is only 16 pounds.

The drill head is made of aluminum, and the machine is finished in black enamel and is furnished complete with a standard attaching plug, connecting cord and a Westcott chuck, which will take all sizes of twist drills up to 5-16 inch in diameter. The drill is useful for all light drilling work within the scope of the hand breast drill, and it may even be used on work ordinarily done on a drill press.

Foote's Patented Combustion Chamber Arch.

The Foote patented back combustion chamber arch was designed in order to make a gas and air-tight combustion chamber which could be easily installed and which would last as long as the boiler. The arch does not touch the boiler, but there is an elastic extension of asbestos between the boiler head and the arch, the latter being ship-lapped together. This makes the installation easy to take down or set up if for any reason it is necessary to move the boiler. Room is also provided for the use of expanding tools when it becomes necessary to expand any of the tubes. These arches are manufactured by the McLeod & Henry Company, Troy, N. Y., from their "Steel Mixture," which is a composition of fire-clay and other materials exclusively their own make. The arch is guaranteed to stand a temperature of 4,000 degrees F. before fusing. The same composition is also used by them for boiler door arches.

The Ashton Standard Test Gage.

Every boiler maker will recognize the importance of having an absolutely accurate test gage, and also the economy of having a durable one. These two qualities have been sought in the design of the Ashton gage, manufactured by the Ashton Valve Company, 271 Franklin street, Boston, Mass. It is made with solid drawn brass steel tubes, and the movements are of solid construction and non-corrosive, having German silver pinions and arbors. The springs are well seasoned to prevent setting. Every dial is marked up separately and accurately to exactly match the mechanism of the gage on which it is to be used. Each gage is most carefully adjusted, tested and graduated before leaving the factory. A gage may be graduated to any desired maximum up to 500 pounds.

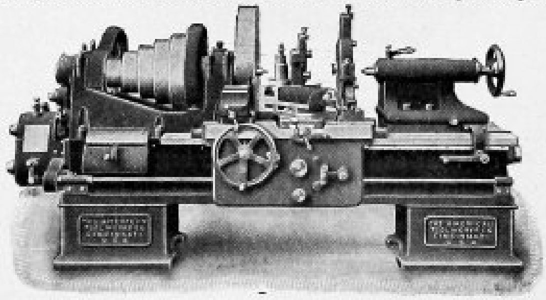
The Barnes Stationary Drill Press.

The machine herewith illustrated is a 26-inch stationary head drill. It is a very strong and stiff tool, and has a particularly strong driving power and feed. It is guaranteed to drill up to 1¾ inches in steel. This drill is regularly built with back gear power feed and automatic stop, the feed mechanism giving also plain lever feed, hand worm feed and quick

return lever, and may be furnished with a reversing friction counter shaft for tapping. The total height of the drill is 84 inches. The distance from the column to the center of the table is 13⅝ inches. The vertical travel of the spindle is 15 inches and the vertical travel of the table is 17½ inches. The greatest distance from the spindle to the base is 45 inches, and the greatest distance from the spindle to the table is 30 inches, while the entire floor space required is 22½ by 63 inches. This machine is built by the B. F. Barnes Company, Rockford, Ill.

The American Lathe.

The American 18-inch lathe has been designed to have an exceptional producing capacity, such as is required by continuous service at high speeds and heavy feeds. The bed is of a deep box girder section, forming one of the strongest known beam sections. The headstock is massive and is equipped with a five-step cone which, with back gears, gives ten changes of speed. The tail-stock is of the offset type, which permits the compound rest to be set in a plane parallel



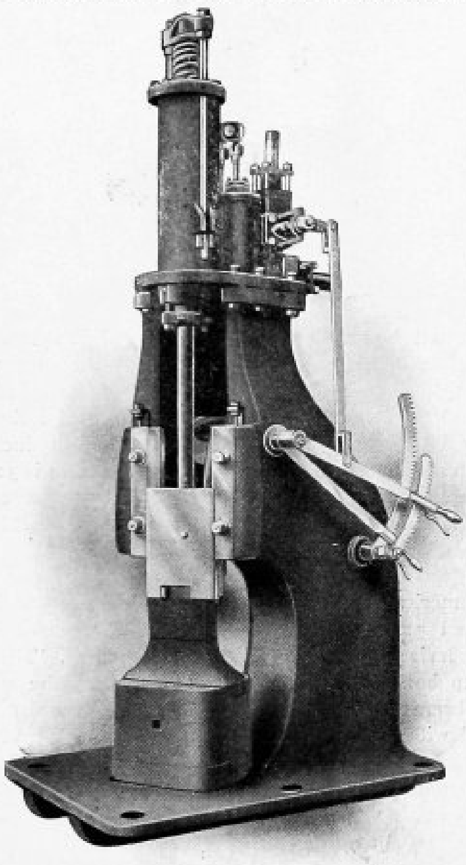
to the bed. Set-over screws and a graduated scale are provided for turning tapers.

In order to avoid any tendency to twist or lift the carriage the lead screw is located inside the bed directly under the cutting tool. The lead screw is used for screw cutting only since a separate splined rod is provided for driving the carriage. All gears used in screw cutting are solid and all shafts are made from high carbon steel, accurately ground. The four-speed box is mounted on the head end of the bed, and by means of clutch members four changes are instantly obtainable, while by means of a cone of eleven gears mounted on the inside of the bed, any one of which can be instantly engaged by means of a heavy tumbler gear, twenty-four changes are obtainable. Simple index plates show the various combinations and how to obtain them, so that any inexperienced hand may use them.

This lathe is manufactured by the American Tool Works Company, Cincinnati, Ohio.

Single Frame Steam Hammer.

The Erie Foundry Company, Erie, Pa., manufacture the single frame steam hammer, which is shown below, for general forging. The rams and dies are set at an angle of 35 degrees, so that a piece of any length can be worked full length on the dies. The anvil is made with a separate cap, keyed to the anvil above the bed plate. The valve motion is so designed that steam is admitted without any wire drawing, and there is no

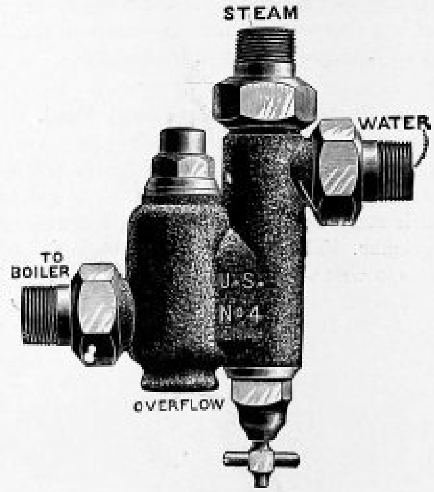


back pressure, the moving parts being made as light as possible consistent with durability. Adjustable guides serve to take up all wear and prevent the rod breaking.

A distinctive feature of this hammer is the automatic safety stock placed on top of the cylinder. A central pin projecting through the center of the head to a point below the top port is supported by a stiff spring and side bars keyed to projections on either side of the cylinder. In the event of careless running or breaking of the rod, the projecting point is struck and the shock absorbed by the spring, thus saving the cylinder or cylinder head from breakage.

The United States Automatic Injector.

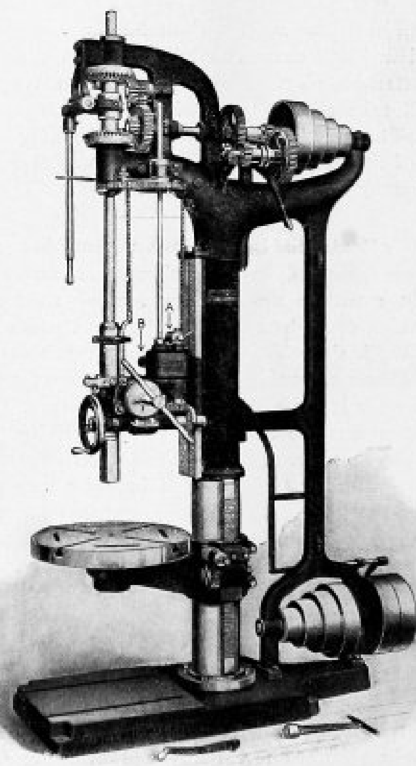
The United States injector, which is manufactured by the American Injector Company, Detroit, Mich., is made with a minimum number of working parts, each one of which is interchangeable in order to reduce the expense of repairs. One of the main features of this injector is the drip cock, by which the injector may be drained when not in use, thus preventing freezing. By leaving the cock open the injector can be started, even should the check valve leak. Also by opening the drip cock the injector may be started with steam of lower pressure than is ordinarily required. The drip cock makes it possible



to draw hot water from a hot suction pipe on a long lift, and it is also handy for drawing hot water for any purpose while the injector is working.

Cincinnati Heavy Pattern Upright Drilling Machine

The drilling machine shown below, which is built by the Cincinnati Machine Tool Company, Cincinnati, Ohio, is made in the following sizes: 24-inch, 28-inch, 32-inch, 36-inch and



42-inch, and is designed to do the very heaviest work called for on upright drills. The ratio of the gearing is very heavy and the feeds are positive and numerous. The particular feature of excellence claimed for this machine is the fact that all round parts, such as the column spindle, sleeve top, and bottom shafts, are finished perfectly by grinding. In addition the gearing is planed and theoretically correct.

THE BOILER MAKER

VOL. VII JULY, 1907 No. 7

LOCOMOTIVE BOILERS IN 1834.

Previous to 1829 progress in locomotive building had resulted in no type of engine which could be said to satisfactorily fulfil the conditions of railway service. Railway companies had been formed and were operating trains with more or less success, using a number of different types of locomotives. The most popular of these was a modification of Hedley's "Puffing Billy," which was built in 1813. The "Puffing Billy" was one of the "grasshopper" type of engines with vertical cylinders and a return flue boiler. In 1828, however, the Liverpool & Manchester Railway offered a prize for a locomotive which would fulfil certain practical conditions, with the result that on Oct. 6, of that year, Stephenson's "Rocket" made its first appearance. While the "Rocket" was not the only locomotive built in competition for this prize,

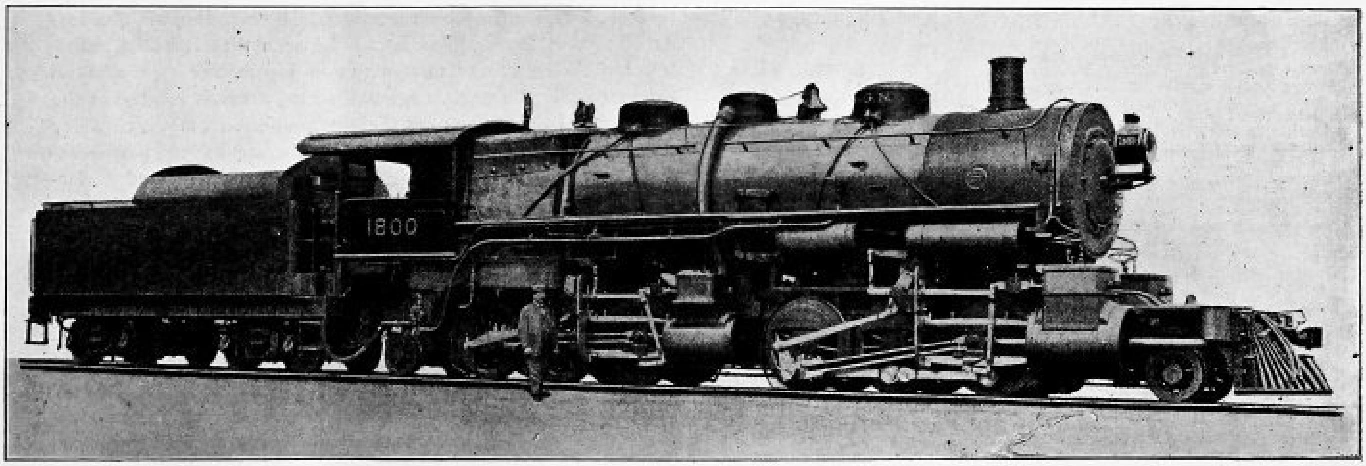
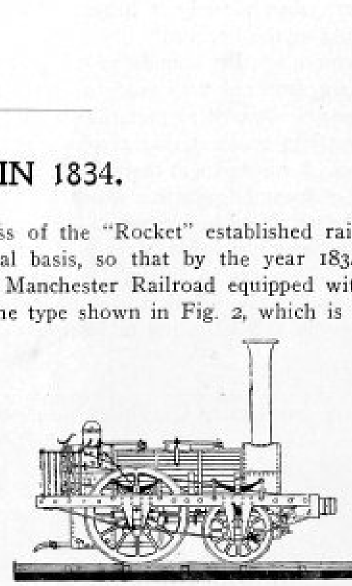


FIG. I.—VIEW SHOWING THE DIFFERENCE IN SIZE BETWEEN A MODERN LOCOMOTIVE AND ONE IN USE IN 1834.

yet it proved such a success that it not only won the prize, but was adopted, in a modified form, as the type of engine to be used on the Liverpool & Manchester Railway for the next few years. The "Rocket" did not possess any new features of design, but embodied a combination of the best features which had been used individually by different inventors before that time.

The principal features which made the "Rocket" successful, and which, in fact, have been used ever since and are prominent characteristics in most modern locomotives, were a tubular boiler, a fire-box completely surrounded by water, and an exhaust steam jet, located in the smoke-box in such a position that the jet of steam going up the stack would increase the draft of the boiler. None of these features were original with Stephenson, for the tubular boiler was invented by a French master mechanic, Marc Seguin, whose patent bears the date Feb. 22, 1828, while Trevithick, Hedley and others had used the exhaust steam jet in the stack quite generally previous to that time.

The success of the "Rocket" established railroading on a more practical basis, so that by the year 1834 we find the Liverpool & Manchester Railroad equipped with thirty locomotives of the type shown in Fig. 2, which is a modification



of the original "Rocket." Up to this time, however, very little had been done towards obtaining scientific data from which any calculations could be made for the power and proportion of the parts of a locomotive. This work was taken up by Chev. F. M. G. De Pambour, who conducted an exhaustive series of experiments on these locomotives, and made public his results in an interesting volume, which was first published in France early in 1835, and in Philadelphia in the following year. In speaking of his work, M. Pambour says:

"We have studied the subject with all the interest and, we might say, with all the enthusiasm it excited in us. In fact, what a subject for admiration is such a triumph of human intelligence! What an imposing sight is a locomotive engine moving without effort with a train of forty or fifty loaded carriages, each weighing more than ten thousand pounds! What are henceforth the heaviest loads with machines able to move such enormous weights? What are distances with motors which daily travel thirty miles in an hour and a half? The ground disappears in a manner under your eyes; trees, houses, hills are carried away from you with the rapidity of an arrow, and, when you happen to pass another train traveling in the opposite direction with the same velocity, it seems in one and the same moment to dawn, to approach, and to touch you, and scarcely have you seen it with dismay pass before your eyes, when already it has again become like a speck disappearing at the horizon."

While the above quotation sounds amusing enough at the present day, when compared with modern speeds and modern loads, yet the results obtained at that time were by no means poor when taking into consideration a comparison of the motive power. Look, for instance at the illustration which shows one of the type of locomotives upon which M. Pambour conducted his researches placed beside one of the largest and most powerful modern American locomotives, and some idea is obtained of the vast difference in power. This comparison is all the more striking when the details and dimensions of the two locomotives given in the following tables are compared and contrasted.

MALLET ARTICULATED COMPOUND LOCOMOTIVE FOR FREIGHT SERVICE ON THE GREAT NORTHERN RAILWAY.

Total length	54 feet 7¾ inches.
Total weight	355,000 pounds.
Weight on the drivers	316,000 pounds.
Tractive effort (compound)	71,600 pounds.
Tractive effort (simple, using live steam in the low-pressure cylinders)	87,200 pounds.
Diameter of drivers	55 inches.
Diameter of cylinders	22½ and 33 inches.
Stroke	32 inches.
Type of boiler	Belpair.
Diameter of boiler	84 inches.
Steam pressure	200 pounds per sq. in.
Firebox, heating surface	225 square feet.
Tubes, heating surface	5,433 square feet.
Total, heating surface	5,658 square feet.
Firebox, heating surface percent of total	3.9
Grate area	78 square feet.
Heating surface ÷ grate area	72.5
Length of tubes	21 feet.
Number of tubes	441
Diameter of tubes	2¼ inches.
Sectional area of tubes, percent area of cross section of boiler	31.5
Firebox, length	117 inches.
Firebox, width	96 inches.
Firebox plates, thickness	⅜ and ½ inch.
Firebox water space, front	6 inches.
side and back	5 inches.
Total weight ÷ tractive effort	4.96
Tractive effort × diameter of drivers ÷ heating surface	698
Total weight ÷ total heating surface	62.75

LOCOMOTIVES USED ON THE LIVERPOOL & MANCHESTER RAILWAY IN 1834.

Total length	15 feet.
Total weight	26,880 pounds.
Tractive effort	2,469 pounds.
Diameter of drivers	54 inches.
Diameter of cylinders	14 inches.
Stroke	16 inches.
Diameter of boiler	3 feet 6 inches.
Steam pressure	50 pounds.
Firebox, heating surface	40.2 square feet.
Tubes, heating surface	416.9 square feet.
Total heating surface	457.1 square feet.
Firebox heating surface percent total heating surface	8.54
Grate area	7.5 square feet.
Ratio of heating surface to grate area	61.1
Length of tubes	7 feet.
Number of tubes	140
Diameter of tubes	1⅝ inches.
Sectional area of tubes percent area of cross section of boiler	21
Total weight ÷ tractive effort	10.89
Tractive effort × diameter of drivers ÷ heating surface	291.9
Total weight ÷ total heating surface	58.8

The modern locomotive shown in the illustration was built in 1906 by the Baldwin Locomotive Works, Philadelphia, Pa., for the Great Northern Railway, and is one of the largest and heaviest locomotives ever constructed. It is what is known as a Mallet compound articulated locomotive, the distinguishing feature of the Mallet type being that it has two separate engines, each operating its own set of drivers. In this particular engine the high-pressure cylinders, which are 21½ inches in diameter by 32 inches stroke, are carried upon the main frame of the engine at about mid-length of the boiler, with which the frame is rigidly connected through the saddle and at other bearing points. Steam is admitted to the cylinders through outside steam pipes leading down on the outside of the boiler from the steam dome, the exhaust from the high-pressure cylinder passes through a flexible joint placed in the vertical axis of the saddle to a pair of low-pressure cylinders, 33 inches in diameter by 32 inches stroke located at the front end of the radial truck, which carries the weight of the forward part of the boiler. From the low-pressure cylinders the steam exhausts to the smokestack through a jointed flexible exhaust pipe. This form of construction provides great flexibility, so that the locomotive, in spite of its great length of 54 feet 7¾ inches, can easily negotiate a 10-degree curve.

The locomotive of the type used in 1834, shown in the illustration, and more in detail in Figs. 2 and 3, is of the most improved type in use at that time. It embodies all the features of the "Rocket," as it will be seen that it has a multitubular boiler of the now common locomotive type and an exhaust jet in the stack. A small steam dome is located at the after end of the boiler over the crown sheet, from which a dry pipe leads to the front end directing the steam into two cylinders 14 inches in diameter by 16 inches stroke, located underneath the boiler inside the driving wheels. The steam is controlled by plain slide valves, and, after passing through the cylinders, exhausts directly into the stack. The frame on which the boiler was supported was very strongly constructed and securely braced. Two separate safety valves were provided, the object being to keep one always set at a cetain pressure, so that the engineer could not crowd the boiler beyond a safe limit.

In comparing the two locomotives and noticing the marvelous strides which have been taken in locomotive building from that day to this, it is interesting to note that the locomotive of 1834 is about one-thirteenth the total weight of the modern locomotive, and is capable of exerting about one-twenty-ninth of the tractive effort, while the number of pounds weight of the locomotive for 1 pound of tractive effort is about twice as great as in the modern locomotive, the total weight divided by the total tractive effort in the case of the Mallet compound

A TABLE SHOWING THE PRINCIPAL DIMENSIONS OF THE TWELVE BEST LOCOMOTIVE BOILERS ON THE LIVERPOOL AND MANCHESTER RAILWAY IN 1834.

NAME OF ENGINE.	Diameter of Cylinder.	Stroke.	Diameter of Boiler.	Length of Tubes.	Number of Tubes.	Diameter of Tubes.	Heating Surface in Firebox.	Heating Surface in Tubes.	Total Heating Surface.	Grate Area.	Ratio of Heating Surface to Grate Area.
	(Inches.)	(Inches.)	(Feet.)	(Feet.)		(Inches.)	(Sq. Ft.)	(Sq. Ft.)	(Sq. Ft.)	(Sq. Ft.)	
Samson	14	16	3.50	7.	140	1⅝	40.2	416.90	457.10	7.50	61.1
Jupiter	11	16	2.75	6.50	79	1⅝	36.06	226.80	262.86	6.08	43.2
Goliath	14	16	3.	7.	132	1⅝	40.31	407.	447.31	7.50	59.6
Vulcan	11	16	3.	6.50	107	1⅝	34.45	307.38	341.83	6.50	52.6
Fury	11	16	3.	6.50	107	1⅝	32.87	307.38	340.25	6.12	55.7
Victory	11	16	3.	6.75	97	1⅝	37.63	278.53	316.16	6.27	50.4
Atlas	12	16	3.	7.88	65	1⅝	57.06	217.88	274.94	9.20	29.9
Vesta	11½	16	2.75	7.	80	1⅝	46.	256.08	302.08	7.06	42.8
Liver	11	16	3.	6.50	97 {70, 27}	{1⅝, 1⅝}	39.66	284.01	323.67	8.11	39.9
Ajax	11	18	2.75	6.66	63	2	32.64	228.14	260.78	6.08	42.9
Leeds	11	16	3.	6.50	107	1⅝	34.56	307.38	341.94	6.19	55.3
Firefly	11	18	3.	7.50	110	1⅝	43.71	362.60	406.31	7.16	56.7

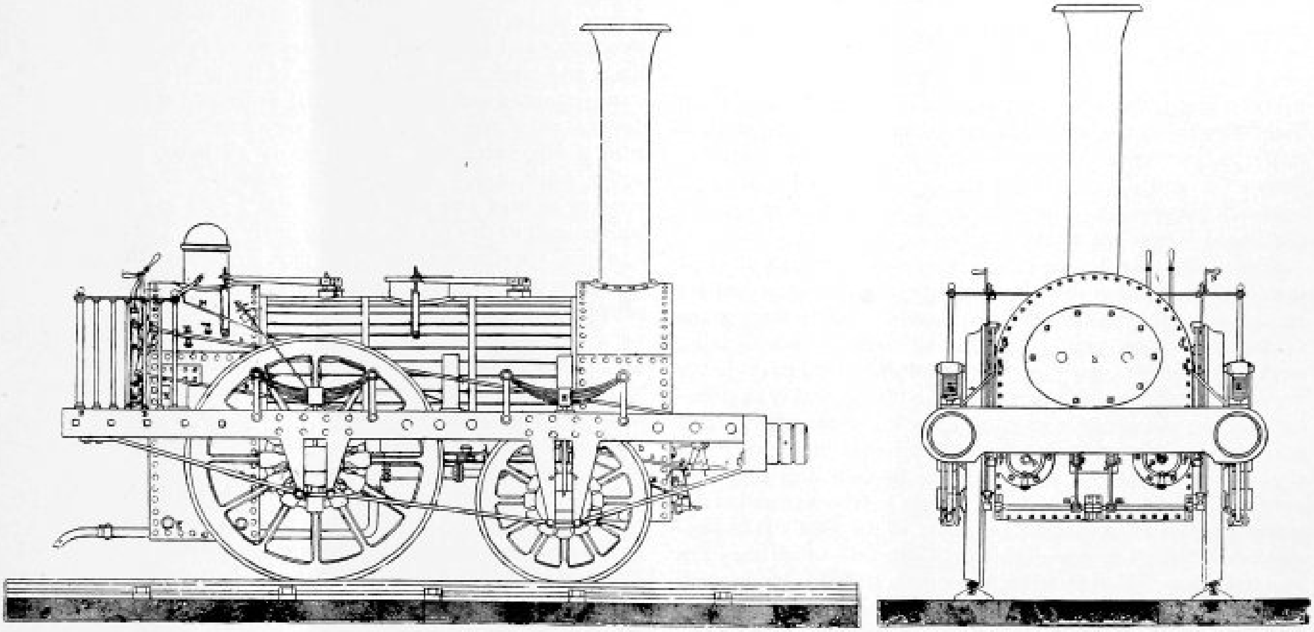


FIG. 2.—DETAILS OF THE TYPE OF LOCOMOTIVE IN USE ON THE LIVERPOOL & MANCHESTER RAILWAY IN 1834.

being 4.96, and in the case of the locomotive of 1834, 10.89. While the diameter of the boiler has been doubled in the modern locomotive, the length of the tubes has been trebled, and the proportion of the cross section of the tubes compared to the cross sectional area of the boiler is about one-third greater in the modern locomotive than in the early type. This is due, apparently, to the fact that in the early locomotives a larger proportion of the boiler was given over to steam space, and also much wider bridges were used between the tubes. The heating surface in the fire-box of the older engine formed 8.54 percent of the total heating surface, while in the modern engine it is only about 3.9 percent. The ratio of heating surface to grate area was fairly large in the early engines and compares favorably with modern design.

Locomotives in use in 1834 on other railways in England upon which M. Pambour experimented, notably those of the Stockton & Dillington Railway, were of various types. In some of these the fire-box passed entirely through the boiler, while in others a single fire tube was bent around at the front end, or divided into two branches, and led the gases back to the chimney at the after end. Many of them had a large number of small return tubes. The latter were used mainly as passenger locomotives, as it was found that the other types did not generate steam rapidly enough for this purpose. Passenger trains on this road were run at an average rate of about 12 miles per hour, and freight trains at an average rate of 8 miles per hour, with a load equivalent to about 60 tons on the level, the average weight of these locomotives being from 10 to 12 tons.

All of these earlier boilers were supported on springs in a manner similar to that shown in the illustration. An attempt was made to use the steam pressure in the boiler in the place of springs, the pressure being exerted on small, movable pistons. This, however, did not prove practical, due to the variation in steam pressure.

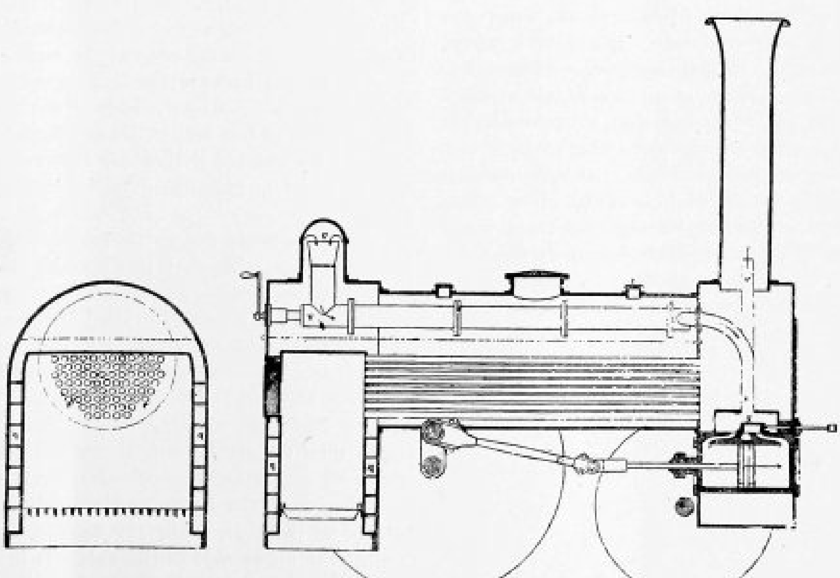


FIG. 3.—DETAILS OF THE BOILER AND FIRE-BOX IN USE IN 1834.

How to Heat and Drive Steel Rivets. *

BY T. C. BEST.

LAYING OUT WORK.

The subject, "How to Heat and Drive Rivets to Make them Tight" begins at the laying-out bench, long before the work is ready to be riveted. Tight work depends largely upon the proper size and pitch of rivets for a given thickness of plate, hence it becomes necessary to say a few words under the caption of laying out work.

Rivet holes must be spaced close enough to permit of good sound calking, and at the same time they should be pitched far enough apart to give the strongest joint obtainable for a given thickness of plate, tensile strength of material and shearing strength of rivets. In triple riveted double butt-strap joints we are confronted with a wide pitch of rivets, and it is essential that the outside butt strap shall be heavy enough to stand good, hard calking without springing the plate up between the rivet holes; especially is this true in small size boilers with light outside butt straps. Most rules which have come under the writer's notice allow for the thickness of the butt straps five-eighths of the thickness of the shell plates to which they are attached; but my costly experience with leaky rivets in such seams in light plates has proven to my satisfaction that 5/16-inch butt straps for a 3/8-inch shell and 3/16-inch butt straps for ¼-inch shells are entirely too light. They should be at least the same thickness, if not heavier than the shell plate to which they are attached, otherwise the sheet springs up between the rivet, under the necessary calking; and if the rivets were absolutely tight in the holes in the inside butt strap and the main shell, the heavy calking, which springs the outside butt strap, forming a water chamber between the shell and outside strap tends to loosen the sheet from around the rivets in the strap, and causes many leaky rivets which are seemingly hard to account for. This trouble is not experienced so much in railroad work, where heavier material is used, but it is experienced almost daily in contract shops where light plates are worked.

SIZE OF HOLES.

Ever since the writer can remember, and as far back as rivet tests have been recorded, it seems to have been the general practice in boiler making to make the rivet holes 1/16 of an inch larger than the rivet. The adoption of a rivet hole 1/16 of an inch larger than the rivet in the early days of boiler making can, no doubt, be traced directly to the iron rivet. Those of us who have heated rivets in the days of iron rivets, have acquired a knowledge of the nature of iron. Iron rivets, when driven by hand, if not brought to a spitting or welding heat, would split at the point and leave small cracks all around the edge of the rivet, which were very apt to cause leaky rivets. On the other hand, if the iron rivet was kept a little too long in the fire with a slow draft it would become bulky on the end which must necessarily enter the hole first. How often have we heated iron rivets and when we removed them from the fire they would appear all honeycombed and swollen on the end, and we found it necessary to hammer them before we could get them into a rivet hole that was even a sixteenth of an inch larger than the rivet, hence the larger the hole the easier an iron rivet was inserted. This being the fact a good sized hole was desirable.

Steel, however, is of a different nature, and when heated to a welding point, runs away like molasses and seldom ever becomes bulky on the point, hence it can be put into a smaller hole than an iron rivet properly heated.

The practice of making the rivet holes 1/16 inch larger than the rivet may have been all right twenty-five or fifty years ago in the days of low steam pressure; but to my mind, it is a serious mistake, and I would ask the question, "Are we to follow in the footsteps of our fathers, in these days of common sense and enlightenment, or are we to keep abreast of the times and meet the new conditions of the present day?" With our pneumatic and overhead radial drills and other improved devices, holes can be reamed at a very small cost as compared with a few years back, hence, nearly all holes, especially in boiler work, are punched smaller than the diameter of the rivet to be used and then reamed, and I dare say all holes in boilers built to-day are almost absolutely fair. The rivet holes, however, are almost always 1/16 inch larger than the diameter of the rivet to be used. Roughly speaking, steel when hot expands about one-eighth of an inch to the foot. Let us consider for a moment whether it is better to punch or drill a hole 1/16 inch larger than the rivet and trust to good luck and strength to fill it up again with the driven rivet by any of the methods now employed in driving, or is it better to make the hole a neat easy fit, so that there will be practically only one-half of the upsetting to be done?

If steel expands one-eighth of an inch to the foot let us reason out what the expansion on a 1-inch rivet would be. A 1-inch rivet would, under this law of expansion, expand 1/12 of ⅛ of an inch. Now, without going into decimals, we can all imagine how small a twelfth of ⅛ of an inch is. I do not contend that we should not allow anything for clearance, but I do contend that we have been allowing too much clearance. In other words, a rivet 6 inches in diameter would expand, when hot, to practically speaking, 6 1/16 inches diameter, hence it will be seen that a rivet hole 1/16 of an inch larger than the rivet would almost admit a 6-inch rivet, and would in all probability receive without any trouble at all a 3-inch rivet, and I ask in the name of common sense, "Should we make the clearance in our rivet holes for a 1-inch rivet as large as that required for a 3-inch rivet, which is three times as large and expands three times as much?"

Let us ask ourselves a simple question, "Why do rivets leak?" There can be but one answer, and that is, "because they do not completely fill the holes in which they are driven." If they did, we would never have a leaky rivet, as we must all agree that it would be impossible for water or liquid to pass between the rivet and the sheet if the hole was completely filled with the body of the rivet.

We have in the past depended largely upon getting the edge of the rivet down close enough to the sheet to make the rivet tight, and in the days of hand riveting we would peck away at the edge of the rivet until it was thin as tissue paper, knowing that if we were to leave the material, say, a 1/16 or an ⅛ of an inch thick on the edge of the rivet in spots it would leak. Why? Simply because the hole in which it was driven was not completely filled by the body of the driven rivet; if it were, pray, how could it leak? In our first lesson in riveting, we cannot help but recall that our instructions from older boiler makers were to plug them in the hole good and they would not leak.

In view of what the writer has said upon the above subject it seems reasonable that if we make our rivet holes smaller it will not be necessary to upset the rivets so much, hence we will have more completely filled holes, and consequently less leaks from around the rivets.

Another objection to large holes, which has direct bearing upon the tightness of rivets, and especially is this true in the case of hydraulic riveting, where the holes are considerably larger than the rivet itself, is that the point of the rivet being long and projecting through the sheet, is often the heaviest, and, therefore, the heavy end will sag down and rest on the bottom of the hole, while the head end of the rivet leans up against the upper side of the hole. It is quite natural that the operator will hoist the boiler so that the outside die will come fair with the head, while the point of the rivet leans down and

* Awarded third prize in the Champion contest.

is far from being in direct line with the center line of the inside and outside dies, and when the pressure is applied the rivet is often driven to one side of the hole and sometimes clinched. Such rivets seldom, if ever, fill the hole and leakage usually occurs. Why? Again, simply because the rivet holes were too large, or the rivet could not lean down out of a true line with the inside dies. If the rivet fits the hole snugly it would retain a position in direct line with both dies, and would be upset directly into the hole by the full power of the machine, hence with the smaller holes we would have less leaks. I am of the opinion that a rivet hole 1/32 of an inch larger than the size of the rivet is plenty large enough in these days of good holes and high steam pressure.

TEMPERATURE REQUIRED IN HAND FORGES.

Perhaps the proper temperature of the furnace in which rivets are heated to produce a perfectly heated steel rivet would be interesting, but to the practical man and the riveter it would be of no value. When rivets are heated in a hand forge with coal or coke, the rivet heater has his hands full in keeping track of the rivets without losing them, no matter how expert he may be, and to apply a thermometer to ascertain the temperature of the fire at the time he removed the rivet would indeed be a nuisance, not only in the fire but it would cause the rivet heater to keep his eyes on the thermometer just at the time he should have them on the rivet he is heating. Then, again, he shuts the blast off to deliver the rivet, and by the time he returns to his fire the temperature has fallen to such an extent that it would be, practically speaking, useless to pay any attention to the temperature. Further, to draw every rivet out of the fire and apply a thermometer to obtain its temperature would be a tedious job, and would hinder rapid progress in the shop by delaying the quick delivery of rivets to the riveter, hence the use of a thermometer in connection with a hand forge would not be practical and could not be used with any degree of satisfaction.

TEMPERATURE REQUIRED IN COAL OF COKE FURNACES.

We will assume, in the case of heating rivets in a furnace, that we are using coal or coke as fuel, as in the writer's opinion the kind of fuel would have no bearing in determining the proper temperature of the furnace or the rivets themselves.

We will, for convenience, consider the old-style furnace in which we are using coal, and let us reason whether or not the use of a thermometer would be practical in this case. We will first light our fire and allow the furnace to heat up, then we will fill up our space with rivets and allow them to become hot enough to suit the various kinds of machines by which they are to be driven. The first batch of rivets becomes hot and they are removed, one at a time, which necessitates the opening of the furnace door each time, so that the temperature of the furnace is gradually lowered and the rivets become somewhat cooler. Then, again, fresh fuel must be supplied, which also changes the temperature of the furnace still further. If the furnace is not a self-feeder a fresh supply of rivets is necessary, which again changes the temperature of the furnace. The result is that the temperature of the furnace is constantly changing, and the matter of waiting until every rivet reaches the same degree of temperature is simply out of the question, and again we find the thermometer useless and impractical.

TEMPERATURE REQUIRED IN OIL OR GAS FURNACES.

Let us now consider the ideal up-to-date oil or gas self-feeding furnace, and see if a thermometer would be of any use to us there.

The furnace is started, the liquid fuel ignites and its heat rays are forced against the brick walls until they are hot. The self-feeder or magazine is filled with rivets, and in a short time they become hot, but from the very moment that the furnace has been started to the time the rivets become hot the temperature has been constantly changing, and because of the fact that the furnace is heated to, say, 1,400 degrees is no sign that all of the rivets in the furnace are of the same temperature as the furnace itself, and from the very fact that no valve was ever made that can automatically regulate the flow of liquid fuel, under all conditions, that would always keep the furnace at an even temperature, the degree of heat will always vary. Also for the reason that the furnace door is sometimes open, then partly open, and often wide open, each one of these conditions tends to change the temperature of the furnace, and to apply a thermometer to every rivet (as stated before) is simply out of the question and would be a source of nuisance; hence, to determine the temperature to which a steel rivet should be heated for the purpose of driving would be impractical, and for the reason that anything that is not practical can never be employed in practice, the temperature at which rivets should be heated must be determined by sight, and not by any complicated device.

OPTICAL DELUSION IN RIVET HEATING.

In rivet heating we are confronted with an optical delusion, for when we look upon a steel rivet in the blazing sun, heated to a spitting or wash heat, it does not appear to the eye to be white, but has more of a red color, yet when away from the sun's rays and in the ordinary daylight, it will appear very nearly white, and in the dark night it will appear almost absolutely white.

This optical delusion which haunts the rivet forge has been the cause of many burnt rivets in the past, and one of the very first things that a rivet heater must do is to become familiar with the true color of rivets heated under the different rays of light. This difficulty is more often experienced out of doors under the bright rays of the sun, which is the most deceiving light known in which rivets can be heated.

THE EFFECT OF HEAT UPON STEEL RIVETS.

The effect that the different processes of heating steel rivets has is of such little consequence that it is scarcely worthy of comment. The condition is there, and it cannot be removed. We all know that to heat a steel rivet with any kind of fuel or in any kind of a forge or furnace, will produce a scale. This is a law of nature which is beyond the control of human power. A portion of this scale, however, is removed from the point of a steel rivet when it reaches a wash heat, but the remander of the rivet still contains a light scale.

The oftener that a steel rivet is heated to a high degree of temperature and allowed to cool off the thicker the scale becomes, and the falling off of this heavy scale from rivets repeatedly heated often fills the space between the rivet and the sheet in the hole with a crumbled mass, which occasionally causes rivets to leak. This is due to the fact that while the boiler is being calked and tossed about this crumbled scale finds escape through the opening between the sheet, and leaves a vacant spot alongside the rivet, through which water may find its way.

THE EFFECT OF COMPRESSED AIR DRAFT.

It has often been said that the effect of compressed air draft when used in connection with oil fuel without a fire wall in the furnace, produces not only a hard rivet but a hard, thick scale on the same. As regards compressed air draft, causing rivets to become hard, it is only an assumption, and right here is the place to ask, "who can positively say that it does?" To the writer's knowledge no man has ever made scientific tests to determine the actual amount of hardness produced in steel rivets through heating them by means of liquid fuel and compressed air, and I would ask, would it not be reasonable to believe that the furnace is always hot enough to absorb all of the moisture contained in compressed air long before it reaches the rivets. If it did not what harm could it possibly do to the body of the rivet? I will venture to say none, from the very fact that any kind of heating of mild steel, such as rivets are made from, tends to anneal it. As rivets are made from mild steel by a similar process to that of our steel boiler plate, and we all know that we can heat this red hot, then quench it in cold water and bend it over double; pray, tell us, what harm a little moisture in a furnace could possibly do to a steel rivet. In the writer's opinion very little, if any.

Then, again, let us take a broad view of it, suppose that if it did have a tendency to make the rivet harder this would be in its favor, as rivets are subject to a shearing strain, and if they become harder after they are driven it would only increase the shearing strength. To make them soft enough to drive it would only be necessary to bring them to a heat that would be best suited for the kind of riveting to be done, whether it be hand, snap, pneumatic, hydro-pneumatic, compression or hydraulic. Therefore, the effect of heat upon steel rivets, aided by forced draft, which includes compressed air, is of so little consequence that it ought not be given consideration by practical men, and the pages of technical books are too valuable to record items of so little value and consequence.

SOAKING STEEL RIVETS.

Common sense and practical experience leads the writer to think that soaking rivets at noon, night or at any other time is not a good thing, yet if they are not allowed to become hot enough to produce a scale it will do but little harm. As stated in a former part of this article, repeated heating of steel rivets to a high temperature and allowing them to cool, or keeping them at a high temperature for a long period of time, will cause a thick scale, which is an unwelcome visitor in any shop where rivets are used.

FORGES AND FUEL FOR RIVET HEATING.

There seems to be but little choice in the particular kind of fuel or forge used for hand riveting, as we find in different parts of the country boys heating rivets with blacksmith coal, with coke, with pea coal, and in some sections with gas or oil, depending entirely upon the kind of fuel they have been taught to heat with, and nearly all of them seem to accomplish equally good results. When blast is to be had the self-feed forge with a magazine on top which holds the fuel, seems to have been quite a favorite in the past few years. It appeals to rivet heaters and others from the fact that the rivet heads are always visible. Oil forges are used very extensively and are the most desirable where oil can be had, but cannot be used to any advantage on outside work, such as repairing old boilers, etc., away from the shop.

Gas forges are better for outside work than oil, as nearly every concern of any size is supplied with gas, but the cost and trouble of making the connections for short jobs, together with the high price of gas, has prevented their becoming prominent as a rivet heater, although they do good work and give perfect satisfaction when arranged stationarily in the shop.

HEATING STEEL RIVETS FOR HAND, SNAP OR PNEUMATIC RIVETING.

The heating of steel rivets to the proper degree of softness is very easily accomplished without the use of a thermometer. Steel rivets heated for hand, snap or pneumatic riveting should be brought to what is known as a wash heat, when the color of the rivet is almost white. The full blast should be turned on suddenly and the point of the rivet quickly brought to a wash heat. By taking hold of the rivet head with the tongs and holding the point downward, continue to shape the rivet in the fire until the desired heat is reached, which can be determined by the long streaks that ascend from the rivet with the blaze, which is caused by the melting of the rivet surface. If, however, stars or sparks appear it is an indication that the rivet is burning. Stars very seldom appear when heating steel rivets under a strong blast, and when the rivet is being continuously shaken in the fire, as steel during the course of its melting becomes glossy and the melted metal always has a tendency to run away from the body of the rivet. A good rivet heater can melt a steel rivet almost completely without burning it if his tongs hold out and he continues to shake the rivet in the fire. In the oil or gas forge rivets can be brought to the desired head with little or no difficulty.

DRIVING STEEL RIVETS TIGHT BY HAND.

The secret of hand riveting lies not only in the proper heating, good, tight fitting and well laid-up sheets, but largely in the strength and ability of the riveters to plug the rivet hard and straight in the hole, the rivet being held up by a good holder-on with the proper tools. While we admire a well-driven and neatly cut-in, hand-driven rivet, yet the cutting in of the edge and a fine finish is unnecessary so far as tightness is concerned, if the body of the rivet completely fills the hole. There are many hand-driven rivets however which do not completely fill the hole, and with these it is necessary to cut all of the edges in to make sure of a good, tight job.

The long-handle sledge for hand riveting is the most desirable tool to hold on with, as it springs just enough to allow the rivet hammers to bound back and takes the strain off the riveter's wrist. It causes a most unpleasant feeling or sensation if we have poor holding-on, and it is just as important to employ a good holder-on as it is to have good riveters. A holding-on sledge should always be high in the center and free from holes or hollow spots. Rivets held on by a sledge with a hollow face, to say the least, make disgusting riveting, as it never sounds solid and usually results in leaky rivets. If the holder-on allows his sledge to slip off the head of the rivet while the riveters are at work their hammers seem to stick to the rivet as if it were a big magnet, and a number of such blows are liable to loosen the rivet; therefore, the tightening of all rivets coming under this class depends largely upon the holders-on as well as the riveters. There are many other ways to hold on for hand riveting, but none are so good or so easy on the riveters as the sledge when in proper condition and in the hands of an expert holder-on.

MAKING SNAP-DRIVEN RIVETS TIGHT.

The snap in the hands of a man who does not thoroughly understand its use will undoubtedly result in many leaky rivets. Many men, even some of our very best boiler makers, do not understand how to drive a good snap rivet.

The secret of snap riveting is a well laid up sheet closely bolted together and a short rivet well plugged in the hole before the snap is applied. It may be held on with any kind of a jigger or jam bar, sledge or pneumatic holder-on; all of these but the sledge may be provided with a cup which fits the head of the rivet, but it should be a trifle smaller, in order that the edges of the rivet head will be forced up tightly to the sheet while the rivet is being driven. Any of these bars are equally good for making tight work, but for convenience as well as quick and tight work a good pneumatic holder-on is preferable.

To make a good, tight, snap-driven rivet the most essential thing of all is to see that the sheets are absolutely close together, held there with a sufficient number of good bolts and riveted with a rivet which will exactly fill the hole and the snap, so that when the rivet is driven and the snap is placed on same and held straight, the edge of the snap will just touch the sheet all around the edge of the rivet. The rivet should first be hit with the sledge and driven down straight in the hole until it is about the depth of the snap cup from the sheets, then place the snap on the rivet, hold it absolutely straight with the same and hit it a few good, hard, fair blows. Then instead of tipping the snap as a great many men do, hold it directly straight with the rivet and scalp the edges. For instance, if you want to get the edge down next to you, hold the snap perfectly straight and raise it up on the rivet about ¼ of an inch, and push against it, after each blow repeat placing the snap in the same position and shove hard until the edge is well down, then if you wish to get the edge down away from you, raise the snap up about ¼ of an inch on the far side of the rivet and pull toward you. Do the same thing with both sides and after all four sides are down, hold the snap directly on the head and hit it two or three good hard blows, and if your holding on is good, and your rivets properly heated, and of a size to exactly fill the cup, you will have good tight rivets.

Never tip the snap in an effort to get the edge down, if you do you will make a horrible looking ring all around the rivet, cut deep into the sheet, and you will kill all the ambition the strikers ever had, by compelling them to strike on the snap in every direction. Also it will require almost twice as many blows to drive a snap rivet, where a man tips the snap, as it does in the case where the snap is held straight with the rivet, therefore tighter rivets can always be made as just described.

DRIVING STEEL RIVETS WITH A PNEUMATIC HAMMER.

The same law that governs snap riveting, also governs pneumatic hammer riveting to a considerable extent. That is to say, the rivet should be long enough to just fill the cup or die and should be driven directly in the hole, without tipping the hammer to one side or the other, any more than is absolutely necessary to get the edge down. The sheets must be laid up as closely as it is possible to get them with the hammer and bolts. For this kind of work, it is especially important that steel rivets be well heated and slipped into the hole quickly while they are still spitting moderately. The hammer should be started up slowly until the operator is satisfied that the rivet is started straight and upset enough so that he will not push it back in the hole, then he can apply the force a little stronger until the rivet is practically formed, after which he can lean the hammer slightly to the edges, and continue the force, finishing the last few blows straight with the rivet. As far as making a tight rivet is concerned, he has then done all that can be done with the hammer, but this is not all that is required to make a steel rivet tight.

Good holding on is absolutely necessary. The sledge cannot be used for holding on with any degree of satisfaction in pneumatic riveting, for it flattens the head out like a pancake, and causes many of them to either fall off or leak when exposed. The best results are obtained from the pneumatic riveter when the pneumatic holder-on is used, and the cup is made on the lines previously described, namely, to fit the rivet head closely, being a trifle small and of such depth as to stand away from the sheet about 3/32 or ⅛ of an inch, so that while the rivet is being driven, the holder-on is forcing the edge of the rivet head up tight against the sheet. This aids in making the rivet heads tight in case they are exposed. If there is very much slack between the sheets, they should be well laid up, otherwise the spring in the sheets will pull the heads off.

TO MAKE STEEL RIVETS TIGHT BY COMPRESSION RIVETING.

Steel rivets for this class of riveting should be heated to a wash heat just the same as for hand riveting, for the reason that such machines are designed to produce a medium pressure and are not built to take the place of the hydraulic riveting machines. Consequently, the rivets must be brought to a good soft heat, in order that the limited power of the machine can form a good point, while the rivet is hot. In compression driven rivets the pressure is usually applied, and then held on the rivet for a few seconds, released and applied again, and also held the second time a few seconds. One of the essential points in this class of riveting is to see that the work to be done, and the machine, are in such a position as to drive an absolutely fair rivet. With close fitting holes, this machine can be made to do fairly good, tight work.

The dies should always be kept in first-class condition for this class of work. The most desirable kind of dies are made from air hardening tool steel, which may last over a year doing constant service without redressing.

The hydro pneumatic riveter would come under this class. It is generally used as a portable machine, and for the same class of work as the compression riveter. For light and medium weight tank work, it is a very good machine. The hydro pneumatic riveter, however, is made for somewhat heavier work, the machine being made heavier throughout, and it can exert a much greater force and will make tighter rivets than any of the pneumatic compression riveters.

HEATING STEEL RIVETS FOR HYDRAULIC RIVETING.

Perhaps more thought has been given to the above subject than the heating of rivets for any other method of riveting, evidently due to the fact that a hydraulic riveting outfit is by far the most expensive; therefore, it commands closer attention, as when a man invests several thousand dollars in a machine, it is quite natural that he will expect good returns upon the investment, and as a result of his outlay, he will keep close watch over this particular machine, and when it is idle, he will have good reason to find out why. If waiting for rivets, he will look around for some better way to heat them, as he cannot afford to have such a machine idle.

This state of affairs has brought about almost an ideal condition around the rivet furnaces of hydraulic riveters, and has been the means of almost universally installing oil furnaces at every machine.

Oil is the ideal fuel for heating steel rivets, assisted by compressed air draft, which is superheated for the purpose of supplying dry air. With oil as fuel, we dispense with:

First. The wheeling in of coal.

Second. The starting of the fire by the watchman about 5 o'clock in the morning.

Third. The wheeling out of ashes.

Fourth. The necessary delay of waiting for rivets, to say nothing of cleaning out the fire.

Oil is the ideal fuel, because the furnace can be heated in a few minutes, and a few moments later rivets will be hot ready for the machine. The most desirable type of oil furnace for hydraulic riveting is a self-feeding furnace. By this, I mean one which is arranged so that a keg of rivets or a shovel at a time can be put into the hopper, and the rivets will feed down into the furnace where the front ones are always hot and ready for the machine. The heater continues to remove those in the front row, while the others roll down to fill the vacancy.

A steel rivet for a hydraulic riveter working under 1,500 pounds of pressure should be brought to a dark red only, never a cherry red, and the supply of oil should be regulated to keep the rivets at this color. If, however, they become hotter, they should be removed from the furnace and placed in the magazine again. The use of coal or coke is so far behind the times for hydraulic machine heating, that there is not room enough on these pages to even consider it as a suitable fuel for the purpose, and it should not be considered where the question is asked, which is the best fuel for heating steel rivets.

DRIVING STEEL RIVETS TIGHT ON A HYDRAULIC RIVETER.

The hydraulic riveter is by far the best machine that has ever been invented for the purpose of driving rivets. It is master of all riveting machines, and does its work with ease, rapidity and tightness.

To drive steel rivets tight on such a machine is a simple problem, after the machine is in readiness, but to get such a machine ready to do good tight riveting is more of a problem. First a good hydraulic pump is necessary, preferably steam driven with ample capacity to take care of the hydraulic system. A good accumulator is also a necessity, as is also an up-to-date outside packed triple pressure riveting machine. The object of the triple pressure is to enable the operator to drive different diameters of rivets without loading or unloading the accumulator, which consumes endless time. Without this feature a machine would hardly be considered up-to-date, for when the accumulator was weighted for 5/8-inch rivets, you could not make 7/8-inch rivets tight with the same pressure, consequently the machine would have to be stopped and the accumulator loaded heavier, or drive the rivets with the light pressure and caik them, all of which is too expensive a proceedure to indulge in in these days of keen competition.

Some concerns use water to change the weight of the accumulator by filling the accumulator tank with water and letting it out for small rivets. Others use an extra set of weights made for the purpose, of cast iron and build a platform around the accumulator, for the purpose of holding the weights which are made to fit the curvature of the outside of the accumulator shell, and are arranged with eye bolts and chains. The accumulator ir loaded for, say, 1,200 pounds of pressure for light work, then if they desire more pressure the accumulator is let down and the desired number of weights hooked on, and the accumulator pumped up. By this arrangement it is an easy matter to obtain any pressure desired in a few moments time, and it is by far the best method of regulating the pressure for old style riveters that has yet come to the writer's notice.

Driving steel rivets tight on the hydraulic riveter depends largely upon the amount of pressure the machine is exerting when rivets are driven. The pressure must be regulated differently for every different size of rivets if you want first-class work. By this I do not wish to be understood to say that 100 tons of pressure which is used for 1¼-inch rivets would not drive a ½-inch rivet tight, because it would be very apt to squash the light sheets out of shape. The pressure that would make a ½-inch rivet tight would not make a 1¼-inch rivet tight. Therefore, a great deal of the responsibility for leaky steel rivets driven on the hydraulic machine can be traced to lack of pressure.

It is also important that the dies be kept in absolutely perfect condition, and in cases where water is not used on the dies, the air-hardening steel is by far the best, while the first cost is much higher than the ordinary tool steel, yet you will save the cost over and over again in a short period of time because of the fact that it is almost impossible for the dies made from good air-hardening steel to get out of shape, while the ordinary tool steel dies must be turned up several times a year. With good dies, good tight valves, close fitting and fair holes, close fitting sheets, the proper pressure and dies exactly in line, rivets heated to a dark red color in the hands of a good operator, tight rivets can easily be driven on a hydraulic machine.

The running of a stream of water on the dies and rivets has become a very common practice. When first introduced, this was looked upon with suspicion; in fact, the writer himself was skeptical and made a thorough investigation with the idea in view of ascertaining whether it was or was not good practice, both for the tightness of the rivets and the effect that the cold water might have upon the plate. After some little investigation, I concluded that it was not harmful in as much as it did not allow the plates around the rivet holes to reach and become charged with the fatal blue heat. We have often seen the fatal blue heat all around the rivets and seams while driving rivets, and it sometimes reaches a distance of, say, 6 inches away from the rivets, which may be responsible for some of the boiler explosions in the past. But when water is used on the dies and rivets, it tends to keep the sheet cool and the fatal blue heat never appears. Hence, from this point of view, it is good practice to use water on the dies and rivets, but the air-hardening tool steel cannot be used for dies when water is used, as it will crumble away and is useless for this purpose. The colder that rivets can be driven on a powerful hydraulic riveter, the tighter will be the rivets, provided, of course, that all other things are in perfect condition; hence, the constant stream of water playing on the rivet tends to cool it, and before the pressure is released, the shrinkage is practically all out of the rivet; therefore, it takes the place of holding the pressure on the rivet so long and produces the desired result. If the pressure is held on the rivets until they are cold, we have but very few leaky rivets provided the pressure is high enough to effect good work.

The riveter packing and valves should at all times be tight and free from leaks.

The hydraulic riveter should be supplied with a good overhead crane, provided with trolley and hydraulic hoist, one that will travel directly across the length of the tower, and not radiate from a center in which only one side of the crane travels. It is highly important that the valves of the hoist are in absolutely perfect condition, otherwise it is difficult to raise or lower a boiler in the machine and stop it exactly where you must have it for riveting. If the valves leak and you hold the pressure on the rivet, you are apt to break your chains or pull the sheet out of shape at the point where the chains are connected.

In conclusion, I will say that after treating on the various methods of driving steel rivets, with a view to making them tight, I cannot refrain at this point from giving the following opinion:

First. The best and most up-to-date fuel for heating steel rivets is oil.

Second. The best way of all to drive and make steel rivets tight is on the world's most famous machine, the hydraulic riveter.

A New Cylindrical Marine Fire Tube Boiler.

BY BENJAMIN TAYLOR.

A new boiler has been patented in Scotland, which is designed to increase the efficiency of the ordinary cylindrical or "Scotch" boiler, particularly when working under forced draught in a closed stokehold. It is the invention of a Mr. Inglis, engineer of Airdrie, and is now the property of the Inglis Boiler Syndicate, Ltd., Glasgow.

The special distinguishing features of the "Inglis" boiler and the claims made for it are as follows:

1. Two extra combustion chambers in which the gases from all the furnaces meet and are thoroughly mixed, by which means nearly perfect combustion is procured with practically no smoke.

2. Twenty percent greater heating surface than in the ordinary cylindrical boiler of the same size, resulting in greater evaporative power.

3. Perfect circulation, which admits of forcing economically without damaging the boiler.

The flame and gases from the three furnaces meet in one common combustion chamber at the back of the furnace bridges. The second combustion chamber, which is in the form of a corrugated flue, conveys the combined gases to the third combustion chamber at the front of the boiler where they enter tubes extending from the front to the back end plates. This ensures that the cold gases from any furnace while being fired are mixed and ignited by meeting the hot gases from the other two furnaces. This effects perfect combustion with little or no smoke. As the gases when they reach the tubes at the front of boiler are of uniform temperature, the principal cause of leaky tube ends is removed, and as the tube plate is at the front of the boiler, the formation of "bird-nesting" on the tube ends when forcing is prevented.

The third combustion chamber in front is formed by a removable water-jacketed cover. This acts as a circulator, and the water-jacket is fed entirely from the very bottom of the boiler and discharges into the steam space.

An exhaustive series of trials of the "Inglis" patent firetube boiler, arranged for forced draught, was made by Prof. Stanfield, of Heriot-Watt College, Edinburgh, in a yard at Glasgow. After the trials this boiler was very carefully examined internally and no evidence of undue strain or "bird-nesting" was observed. Any dust or scoria carried over with the flue gases was almost entirely deposited in the back combustion chamber, and the small plain tubes were practically free from dust, etc. No leakage could be detected at the ends of any of the tubes; the only leakage (very slight) was at three or four of the back water-space stays in the first combustion chamber.

When a boiler of the ordinary Scotch type is worked under even a moderate forced draught, the strains induced in the various parts must be excessive and cannot but have an injurious effect on the boiler in general. But in the "Inglis" boiler, says Prof. Stanfield, there appears to be a more equable distribution of strain, the temperature is more uniform throughout, the circulation is most efficient, and the temperature of the escaping flue gases is remarkably low even when working with a pressure of 3 inches of water in the stokehold.

The following are the general dimensions of the boiler tested by Prof. Stanfield, drawings of which are shown on this page.

Single-ended marine steel boiler, with corrugated flues.

Length of shell, 11 feet. Mean diameter of shell, 14 feet, Three furnaces 3 feet 4 inches in diameter, with grates 5 feet 6 inches long.

Return corrugated tube 3 feet 4 inches minimum diameter and 8 feet 2½ inches long.

Three hundred and nine tubes 2½ inches external diameter and 11 feet long.

Heating surface 47.6 times the fire-grate area.

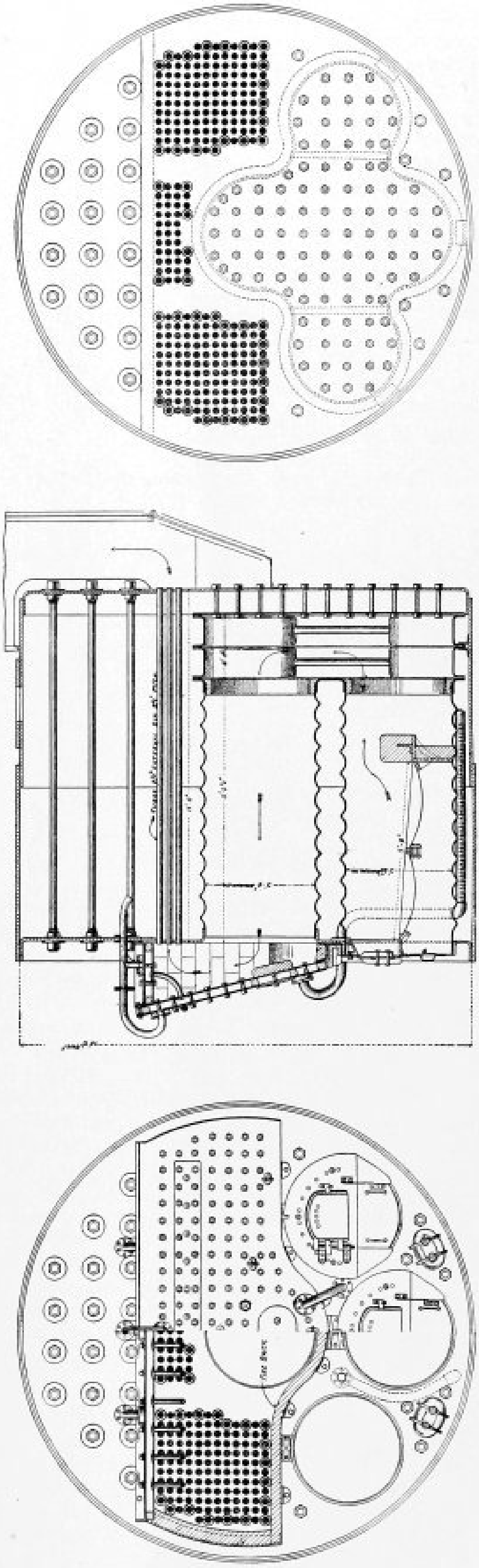
Total grate area (excluding dead plate), 55 square feet.

Total effective heating surface, 2,620 square feet.

The results of these trials are reported by the professor as exceedingly satisfactory. The combustion of the fuel was nearly perfect, and there was practically no smoke visible at the top of the chimney when burning about 20 pounds of coal per square foot of grate area per hour.

A steam-raising trial was made to ascertain the rapidity with which steam could be raised, starting with everything cold. The fires were lighted at 2:51 P. M., and at 4:12 P. M. the steam pressure was 180 pounds gage; total time, 1 hour 21 minutes. At the start the pressure of air in the boiler house was 0.30 inch of water, and at the end of the run it had risen to 1.0 inch; at this time the water below the furnace tubes was quite hot, showing that the water chamber at the front of the boiler combined with the tubes connecting it with the steam and water spaces respectively forms an efficient circulator.

At the annual meeting of the Boiler Maker Supply Men's Association, Mr. George N. Riley, of the National Tube Company, Pittsburg, Pa., was elected chairman of the finance committee, and Mr. J. F. Duntley, of the Chicago Pneumatic Tool Company, Chicago, Ill., chairman of the entertainment committee.



FRONT VIEW, LONGITUDINAL SECTION AND REAR VIEW OF THE INGLIS FIRE TUBE MARINE BOILER.

The Expansion Stresses in Locomotive Boilers.

BY F. DOUGLAS WILKES.

In this article the endeavor of the writer will be to point out the direct cause for so much trouble from leakage in locomotive boilers and how, in his opinion, the difficulty may be overcome or to a great extent lessened.

In stationary boilers of the ordinary tubular type this defect is not so apparent because the heat is perhaps more evenly distributed, and apart from this the boilers of this type are so constructed as to have no two plates in close proximity to one another (and stayed to each other), one of which is heated to a much greater temperature than its neighbor, and as a consequence expands considerably more.

In locomotive boilers we have this unequal expansion in the walls of the fire-box. These walls, until recently, have always been stayed with rigid water space stays. We will now see what happens in these walls and stays when heated to high temperatures. The fire-boxes and shells of locomotive boilers often show deformities, which have their origin in these unequal expansions in the inner and outer walls, due to the lack

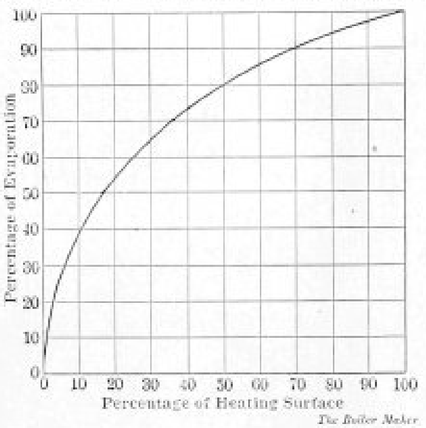


FIG. 1.

of uniformity in the temperature of the sheets in contact with the gases or water, and also due to an insufficient amount of elasticity in the inner parts.

To find the amount of this expansion we must know the mean temperature of the plates exposed to contact with the fire, and to find this temperature we must know the condition of the surface of the plates on the water side, and how much water per square unit of surface is evaporated per hour, arriving at this last by finding the total evaporation per hour. Many tests have been made to determine the evaporative power of locomotive boilers, and from these it is comparatively easy to find approximately how much a boiler of given dimensions can evaporate. We have, therefore, only to ascertain what percentage of this evaporation is due to the tubes and what to the fire-box.

In the text book on railroading by Couche the minute tests and experiments of Geoffroy and Delebecque, engineers of the North Railway of France, are published, and are of great interest and value. Based on the results of these experiments the diagram, Fig. 1, gives, in percentages, the evaporation and heating surface, so that when the percentage of the total heating surface contained in the fire-box is known, the corresponding percentage of evaporation for the same can be read off immediately. We can see, by following the curve in the diagram, how quickly the ratio of evaporation in the flues diminishes towards the smoke-box. Taking, for instance, the first and last 10 percent of the heating surface we find from the diagram that the first 10 percent evaporates 38 percent of the total amount, whereas, the last 10 percent only 3 percent. From these figures we can find the evaporation of each square unit of heating surface of the fire-box and of each square unit of tube surface.

To ascertain the plate temperature from the evaporation we make use of the diagram shown in Fig. 2. For this diagram we are indebted to Hirsch, and it is to be found in the "Annales du Conservatiore des Arts et Meliérs, Paris, 1889. The

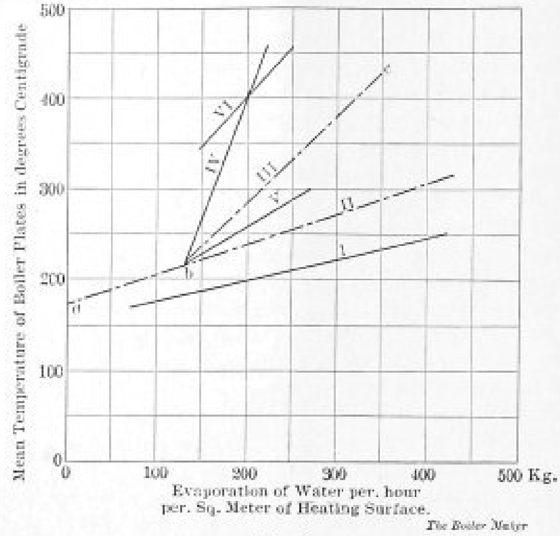


FIG. 2.

vertical lines represent the mean temperature of plate in degrees centigrade, and the horizontal lines the kilograms (2.21 pounds) of water evaporated per hour.

The lowest "curve" *I* represnets the results obtained with a clean plate surface and distilled water, curve *II* of plates with a scale deposit of 1 mm. (.039 inch) thickness, curve *IV* of plates with a scale deposit of 5mm (.195 inch) thickness, curve *V* of plates rubbed in or coated with mineral oil, curve *VI* of double plates with a very thin layer of tallow between. As a scale deposit of 1 mm. seems a little low, and that of 5 mm. rather high, we will divide the angle between *II* and *IV*, obtaining curve *III*, which will give us the temperature of plates having a scale deposit of 3 mm. (.117 inch) thickness, which approaches more approximately ordinary working conditions. As Hirsch's experiments were conducted with open valves and at atmospheric pressure, that is, at 100 degrees C. steam temperature, we have to add to the plate temperature found in the Hirsch diagram the steam temperature less 100 degrees.

Take, for example, an evaporation of 220 kilograms per square meter (45.06 pounds per square foot) at 12 atmospheres

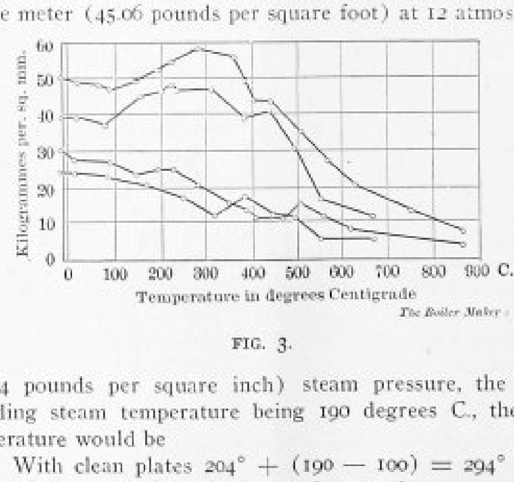


FIG. 3.

(176.4 pounds per square inch) steam pressure, the corresponding steam temperature being 190 degrees C., the plate temperature would be

With clean plates $204^\circ + (190 - 100) = 294^\circ$
With 1 mm. scale $245^\circ + 90^\circ = 335^\circ$
With 3 mm. scale $300^\circ + 90^\circ = 390^\circ$
With 5 mm. scale $450^\circ + 90^\circ = 540^\circ$

From the temperatures found the expansion of the tubes and fire-box sheet can be computed. In so doing we will take the coefficient of expansion to be about (1/850) for steel and iron for each 100 degrees C. The stresses created by these expansions have to be figured out and the diagram shown in Fig. 3 will enable us to decide when the elastic limit or the ultimate strength is reached. The two top lines show the ultimate strength of steel and iron and the two lower lines their elastic limit as found by experiment by the United States Navy. It is interesting and instructive to observe how the ultimate strength steadily increases with the temperature up to about 300 degrees C., where it reaches its maximum, whereas the elastic limit drops steadily with the increasing temperature.

Let us take, for example, a locomotive boiler which evaporates a mean amount of 7,000 kilograms (15,435 pounds) of water per hour at a steam pressure of 12 atmospheres (176.4 pounds), and whose total heating surface is 119 square meters (1,281 square feet), the fire-box containing 9 square meters (97 square feet), or 7½ percent, and the tubes 110 square meters (1,184 square feet), or 92½ percent. Referring now to Fig. 1 we find that the fire-box with its 7½ percent total

In the walls of the fire-box this expansion takes place from the mud-ring upwards and outwards, but as the portions of the plate close to the ring are actually cold, or very cool, the expansions at this point are negligible. In Fig. 4 the arrows show the probable direction of the motion of the molecules of the plates in expanding; upwards from the mud-ring, where the plates are anchored, and outwards from the central or neutral portions. The amount of elongation of the sheets at each row of stay-bolts gradually approaches the maximum, which is obviously at the top row and the upper stay-bolts in the outer row. Again, it is perfectly clear that as the plates are continually being heated and cooled these stay-bolts will be subjected to a vibratory motion. Now, if these stay-bolts were of a rigid type and made of iron of a close, short fibrous structure, dense and hard, with a correspondingly very high tensile strength, the plates would be the parts to give and would probably bulge or crack. On the other hand, if these rows were fitted with flexible stay-bolts they would give and take with this transverse strain and thus tend to equalize the stresses.

Let us go back to the boiler under consideration and find out

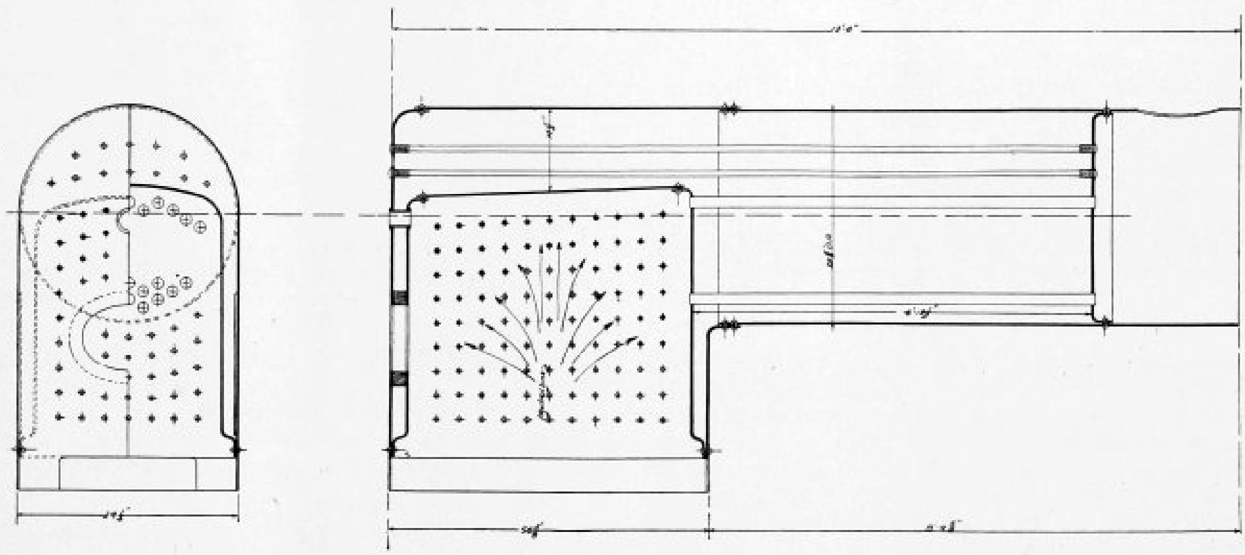


FIG. 4—DIAGRAM OF A LOCOMOTIVE BOILER, SHOWING THE PROBABLE DIRECTION OF THE EXPANSION STRESSES IN THE FIRE-BOX.

evaporates 32 percent of the 7,000 kilograms, or 249 kilograms per square meter (51 pounds per square foot), while the tubes evaporate 68 percent, or 4,760 kilograms, or 43 kilograms per square meter (8.81 pounds per square foot). Looking up the diagram, Fig. 2, we find the mean temperature for the fire-box to be $333^\circ + 90^\circ = 423^\circ$, and for the tubes $183^\circ + 90^\circ = 273^\circ$. This would give an expansion or elongation for the various parts as follows:

	mm.	Ins.
Stay-bolts	0.22	0.009
Fire-box	16.36	0.638
Tubes	15.52	0.605

Figured from the regular formula:

$$\text{Elongation} = \frac{1}{850} \times \text{length} \times \frac{\text{temp. cent.}}{100}$$

It might be noticed here that the elongation of the stay-bolts (being, comparatively, very short) is so extremely small as to pass out of our calculations.

The expansion of the outer shell, taking the length as 6.211 m. would amount to 13 mm. Therefore, the expansion of the inner parts of the boiler is 18 mm. more than that of the outer, taking the sum of the expansions of the inner parts as found above, exclusive of the stay-bolts. This difference equals .73 or nearly ¾ inch.

the amount of this movement. The fire-box of this boiler is 1.45 m. high. The sheets here would be subjected to at least 450 degrees, and if much scale has accumulated to as high as 500 degrees. The expansion, therefore, worked out as before, would equal 11.25 mm., or .44 inch, whereas the outer sheets would expand only 3.08 mm., a difference of 8.17 mm., or 0.32 inch. The front or tube sheet would probably expand even more than this amount, as it is this sheet that is subjected to the highest temperature, and if it were rigidly stayed the resulting bulging would obviously be very dangerous, as it is here that the tubes exert a longitudinal pressure due to their expansion. If the plates are the stronger and do not give then the stays will be given that same strain that we so often use when breaking a piece of wire when no pliers are handy, and with exactly the same result, namely, they become fatigued and eventually break.

In Fig. 4 is shown a locomotive boiler of the traction type, which has been fitted with flexible stay-bolts in order to allow for the expansion stresses in the fire-box. The installation of flexible stays is shown by the full circles, and it will be noted that this installation conforms to the general practice of locomotive construction. The use of flexible stay-bolts seems now to be the best method of overcoming the leakage in locomotive boilers caused by the expansion stresses in the fire-box.

How to Lay Out a Tubular Boiler.

PART VII.

STEAM DOMES.

The use of steam domes on boilers is fast becoming obsolete, especially where high pressures are used, but their wide use in the earlier days of boiler making makes some consideration of their construction necessary.

Several things must be considered with the dome, viz., how it is fastened to the boiler, the style of the vertical seam, the dome head, the bracing, etc. There are in use two general methods of attaching the dome to the shell, one by flanging the dome and the other by having a separate dome base or collar. The latter is generally used in locomotive boiler construction, mainly on account of the size of hole that has to be cut in the shell sheet in order to put in the dry pipe and fittings. The general practice with most boiler manufacturers is to dish the head so that it will be self-supporting.

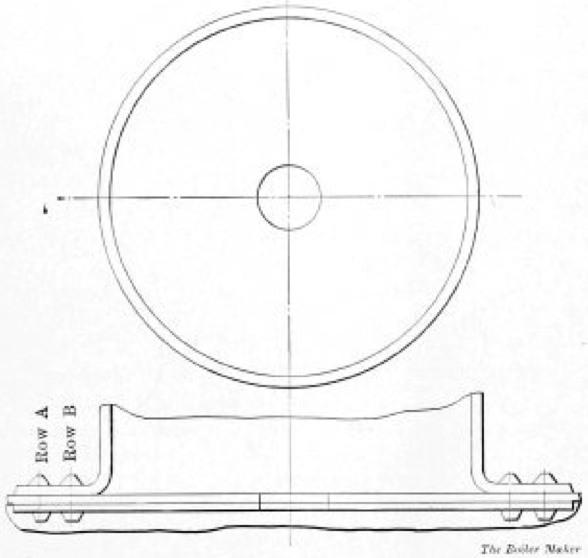


FIG. 38.

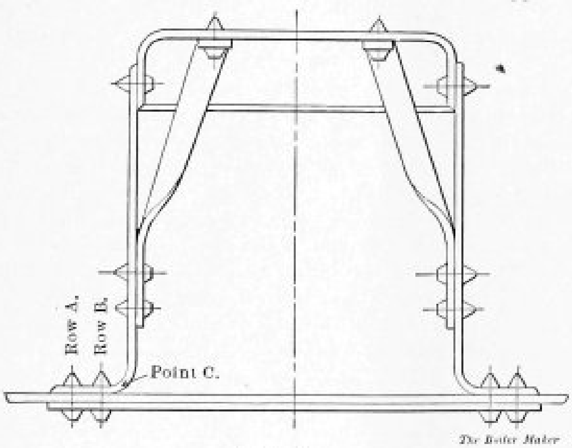


FIG. 40.

There is no set rule to govern the diameter or length of the dome, as large and small domes are used indiscriminately, and frequently the same size dome is placed upon several different sized boilers.

NEUTRAL SHEET UNDER DOME.

The neutral sheet under the dome derives its name from the fact that it is subjected to pressure from both sides. There are several methods of providing for the passage of steam through the neutral sheet into the dome. Some punch out a hole in the center one and a half times the diameter of the steam outlet, while others perforate the neutral sheet with a great number of small holes. The latter method is used in order not to weaken the sheet to such an extent as when a large hole is punched. Some claim that placing a dome on a boiler brings an unequal strain upon the shell sheets, due to the fact that the pressure on the dome is borne by the shell sheet where the dome is attached. Authorities differ on this point however. The use of a liner inside underneath the dome is advocated for strength to cover any weakness that might exist from attaching the dome. In Fig. 38 is shown the neutral sheet with a large hole in the center to permit the steam to enter the dome. Fig. 39 shows the neutral sheet perforated.

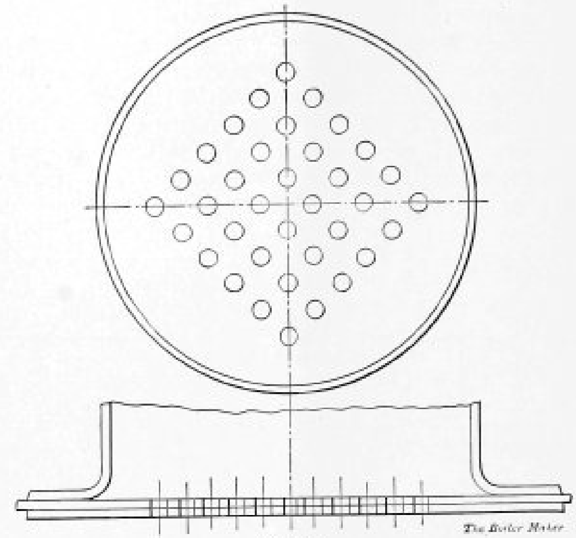


FIG. 39.

BRACING THE DOME.

Steam domes may be braced in two ways: First, as shown in Fig. 40 by diagonal braces from the dome head to the dome shell; and, second, as in Fig. 41 by through stays from the dome head to the boiler shell. The diagonal stays in Fig. 40 serve the purpose of bracing the dome head, but do not take any of the load from the joint where the dome is riveted to the boiler shell. On the other hand, the direct braces, as shown in Fig. 41, carry a part of the load which would other-

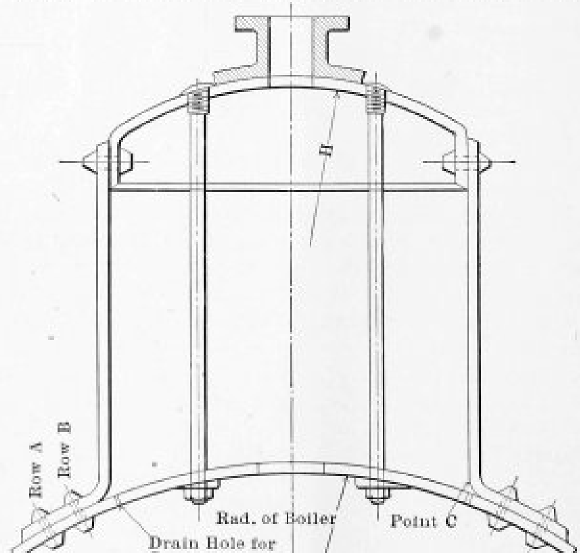


FIG. 41.

wise come upon the joint between the dome and shell. Assuming the inside diameter of the dome as 26 inches, the area of the dome head will be 530.93 square inches. At 175 pounds steam pressure, there is a stress tending to tear the dome from the shell of $530.39 \times 175 = 92,819$ pounds. Assuming that the dome sheet is ⅜ inch thick, and that the joint between the dome and boiler shell is double riveted, so that 70 percent efficiency will be obtained, the total stress which the joint will stand will be $60,000 \times .375 \times 26.375 \times 3.1416 \times .7 = 1,305,040$ pounds.

$$\frac{1,305,040}{92,819} = 14, \text{ the factor of safety.}$$

A large factor of safety should always be used when computing the strength of this part of the dome, since the sheet is almost always thinned out in the process of flanging; also unknown strains may be set up in the plate due to unequal heating and cooling of the metal, or a weakness may be developed through careless hammering or workmanship. In Fig. 41 the dome head is dished, and therefore does not require bracing. In this case the braces merely protect any weakness at the joints *A*, *B* and *C*.

Fig. 42 shows a dome base or collar. If the base is made out of heavy material there is no danger of any weakness at *A*, *B* or *C*, and the dished head can be used without stays.

DISHED HEADS.

The dishing of the head makes it able to resist pressure, the greater the dish the more the pressure allowed, until the

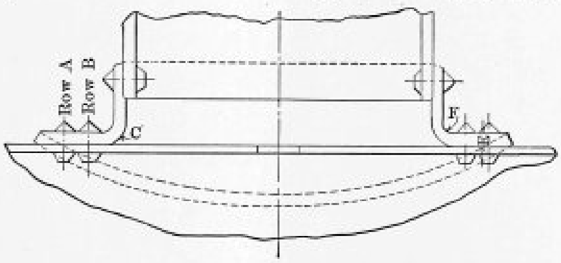


FIG. 42.—DOME COLLAR.

head is hemispherical and then it reaches its limit. It is customary to make the radius of the dished head equal to the diameter of the dome or shell to which it is attached.

The United States rule for convexed heads, as amended January, 1907, is

$$\frac{S \times T}{R} = P$$

Where

P = Pressure allowable per square inch in pounds,
T = Thickness of head in inches,
S = One sixth of the tensile strength,
R = One-half the radius to which the head is bumped.

Add 20 percent when heads are double riveted to the shell and all holes fairly drilled.

Substituting values we have for the head under considera-tion $\frac{10,000 \times .375}{13} = 288.5$ pounds. Adding 20 percent for double riveting we have $288.5 \times 1.20 = 346.2$ pounds, pressure allowed.

According to a different rule, if

T_s = Tensile strength,
T = Thickness of plate in inches,
R = Radius to which the head is dished,
F = Factor of safety,
P = Pressure allowed,

$$\text{then } P = \frac{T_s \times T}{R \times F}$$

Referring to previous work we find that our factor with holes reamed was 4.2. We will therefore use this factor in our example $\frac{60,000 \times .375}{26 \times 4.2} = 206$ pounds.

It will be seen that neither of these rules figure on the net section of plate at the rivet joint where the head is attached to the shell. The United States rule allows different values for single or double riveting, but does not mention what

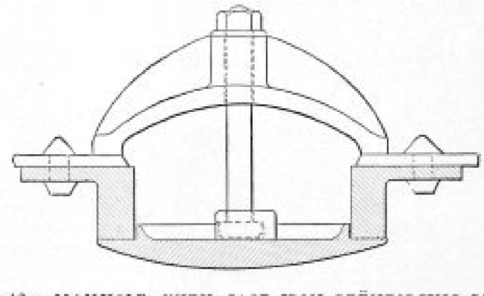


FIG. 43.—MANHOLE, WITH CAST IRON REËNFORCING RING.

efficiency is required. We will assume that it is expected that the net section of plate and rivets compare favorably.

Assuming that the head is dished so the weakness is at the net section of plate, we will figure this out to ascertain what factor we will have. Using the constant 1.31 as in previous work, we have $1.31 \times .375 + 1.625 = 2.12$ inches, approximate pitch. The circumference corresponding to the mean diameter of the dome (26⅜ inches) is 82.86 inches. Divide this by the approximate pitch for the number of rivets. $82.86 \div 2.12 = 39.1$, say 40 (number of rivets). $82.86 \div 40 = 2.0715$ inches, exact pitch.

Using ¾-inch rivets with 13-16 inch holes we have $2.0715 - .8125 = 1.259$ inches. $1.259 \times 60,000 \times 40 \times .375 = 1,134,000$ pounds, strength of net section of plate for single-riveted joint.

$$\frac{1,134,000}{92,912.75} = 12.2 \text{ factor of safety.}$$

The strength of the rivets to resist shearing is $40 \times .5185 \times 42,000 = 871,080$ pounds.

Thus, $871,080 \div 92,912.75 = 9.4$ factor for the rivets. Thus, a single-riveted joint with a properly dished head will give a large margin of safety for a 26-inch diameter dome.

MANHOLES.

Manholes are placed in boilers of the larger sizes in order to give an entrance to the boiler. The manhole should be

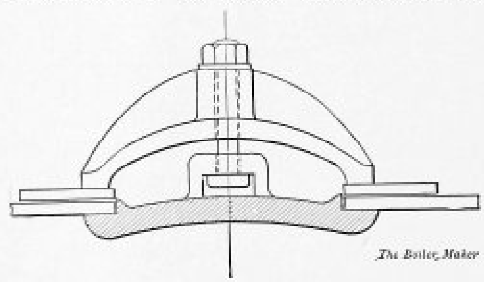


FIG. 44.—MANHOLE REËNFORCED WITH STEEL LINER PLATE.

large enough to permit a man to enter easily, but not larger than is absolutely necessary, as such a cut in the shell must be strongly reinforced in order to preserve the strength of the boiler. This reinforcement is accomplished in several ways. In the older boilers a cast-iron supporting ring, as shown in Fig. 43 was used. Due to the lack of homogeneity, the low tensile strength and blow holes, which are frequently found in iron castings, cast iron has gradually fallen into disuse for any purpose in boiler work. It has been supplanted by steel in this as in almost every other instance. The more modern method of reinforcing a manhole is shown in Fig. 44, where a liner plate is used. The liner may be placed either on the inside or outside or on both sides of the shell. There are a number of patent manhole covers, saddles and yokes on the market to-day which are widely used for this purpose, and might be said to give the best satisfaction, as they are specially designed for a steam-tight joint and maximum strength with a minimum amount of material.

A calculation which must frequently be made is that for finding the size of liner necessary to compensate for the strength lost by cutting the hole. Assume that the manhole is 11 by 16 inches, which is the usual size, although 10 by 15

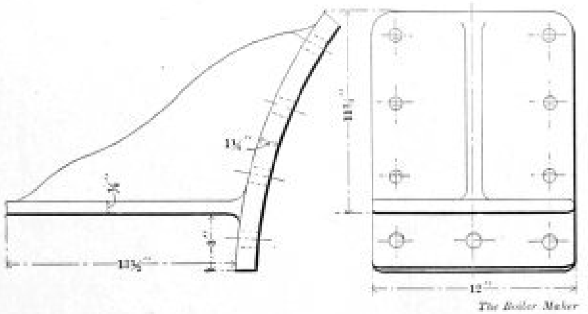


FIG. 45.—CAST IRON WALL BRACKETS.

inches is also frequently used. The minor diameter should run lengthwise of the boiler, therefore we must replace a section of plate 11 inches wide and of the same thickness as the boiler shell. As the boiler shell is 7-16, or .4375 inch thick, this area is $11 \times .4375 = 4.8125$ square inches. Either the width or thickness of the liner must be decided in order to determine the other dimension. Assume that the liner is 9-16 inch thick, its width will then be $\frac{4.8125}{.562} = 8.59$ inches. One-half of this will be on each side of the hole, and for the total width the diameter of the rivet holes must be added to this, making, if ¾-inch rivets are used, 10¼ inches for the total width.

Having determined the size of the manhole liner we must now direct our attention to the size and number of rivets

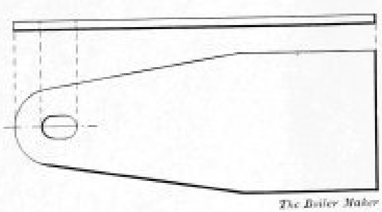


FIG. 46.

necessary in the liner. We found the sectional area of the plate to be 4.8125 and as the steel has a tensile strength of 60,000 pounds per square inch of sectional area the strength of this section is $4.8125 \times 60{,}000 = 288{,}750$ pounds. The shearing strength of the rivets being figured at 42,000 pounds per square inch, the strength of one rivet, using 13-16-inch rivets is .5185 (area one rivet) $\times\ 42{,}000 = 21{,}777$ pounds. Thus, 288,750 divided by $21{,}777 = 13.3$ rivets. This would be the number of rivets needed on each side of the center.

With 15-16-inch rivets (area .69), we would have $42{,}000 \times .69 = 28{,}980$ pounds per rivet, and 288,750 divided by $28{,}980 = 10$ rivets on each side of the center.

SUSPENSION OF THE BOILER.

The two most common methods for suspending boilers are by means of hangers and wall brackets. Cast-iron wall brackets, as shown in Fig. 45, were formerly extensively used, but patent steel brackets have replaced them in many instances for the reason that equally strong steel brackets may be made of lighter weight and at a less cost. Also a steel bracket may be riveted to the shell by an hydraulic riveter, thus ensuring tight rivets. The hanger in Fig. 46 is advocated by some authorities to be used on one end of the boiler so that in the event of the boiler getting out of place, due to the sagging of the brick wall, it can be adjusted by merely tightening up the nuts on the U-bolt.

The general practice has been with wall brackets to place them staggered on the boiler so that a number of boilers could be placed side by side, and the wall brackets clear each other. Many are to-day advocating the use of wider walls, permitting the brackets to be placed in the same relative position on both sides of the boiler. The distance from the end of the boiler at which the bracket or hanger should be placed is sometimes made one-quarter of the length of the boiler. It is claimed that this will not cause any undue strain on the center circumferential seam. This rule will not apply to a two-course boiler, however, as the quarters at each end have the additional weight of the flue heads, flues, and braces.

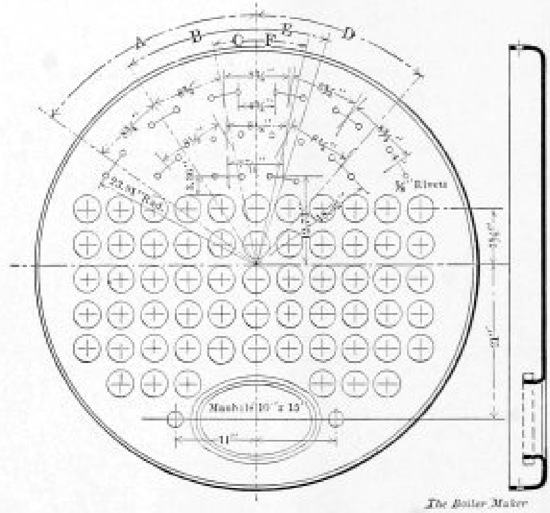


FIG. 47.—LAYOUT OF FLUES AND BRACES.

These weights and also such fittings as the dome, steam nozzles, etc., should be considered in determining the position of the brackets and hangers, rather than any arbitrary rule, such as making the distance from the end of the boiler to the hanger 25 percent of the total length.

NUMBER OF RIVETS IN THE HANGER OR BRACKET.

The rivets in the brackets or hangers will be in single shear, and in order to find the number required it is necessary to know the weight of the boiler and its contents, including all fittings and fixtures. It is the general practice to figure that one-half of the brackets or hangers are to carry the whole weight, as it is considered that at some time the boiler may be displaced from its true setting so that an excessive strain will fall upon one end.

If $A =$ Total weight upon the rivets,
$B =$ Area of one rivet,
$C =$ Shearing strength of one rivet in single shear,
$D =$ Number of rivets for one end,
$F =$ Factor of safety,

$$\text{then } D = \frac{A \times F}{B \times C}$$

Assuming as the total weight for the boiler and details 12 tons or 24,000 pounds, and using ¾-inch rivets and a factor of safety of 12, we have for $D \frac{24{,}000 \times 12}{.5185 \times 42{,}000} = 13.2$ or four-

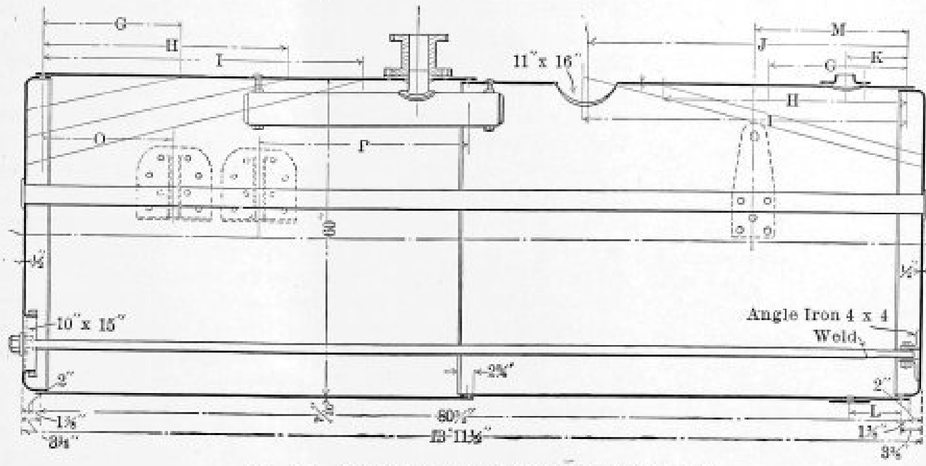


FIG. 48.—SECTIONAL VIEW OF COMPLETED BOILER.

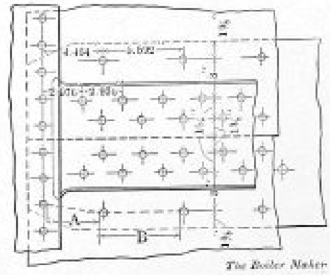


FIG. 49.—DETAIL OF SEAM SHOWN IN FIG. 52.

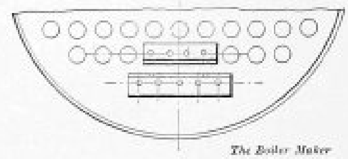


FIG. 50.—DETAIL OF BRACING ON LOWER PART OF BACK HEAD.

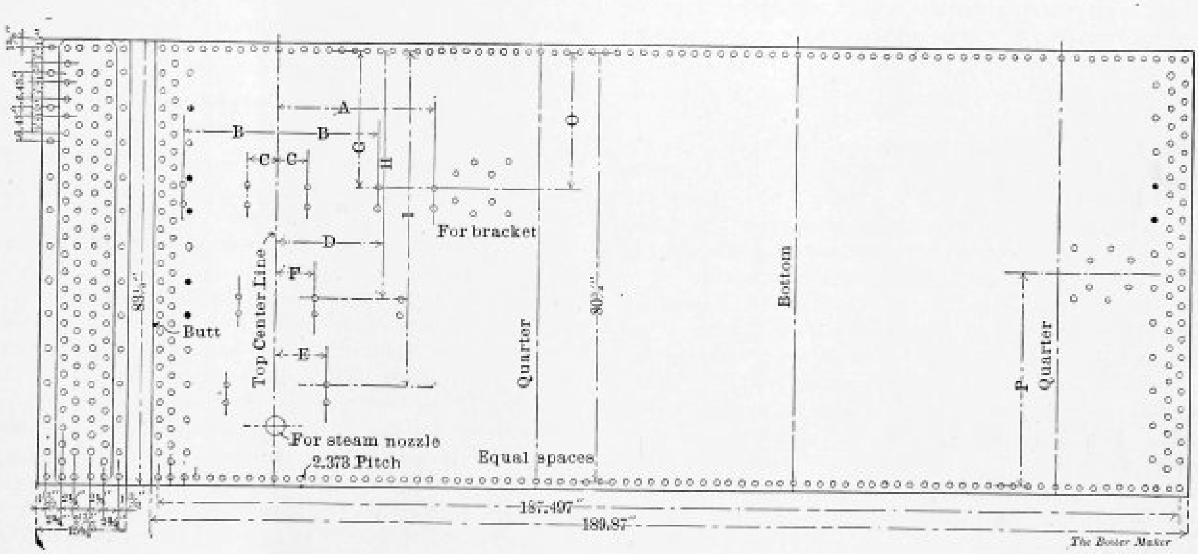


FIG. 51.—LAYOUT OF OUTSIDE COURSE OF SHELL, WITH LONGITUDINAL SEAMS FIGURED ACCORDING TO PRACTICE OF THE HARTFORD INSPECTION AND INSURANCE COMPANY.

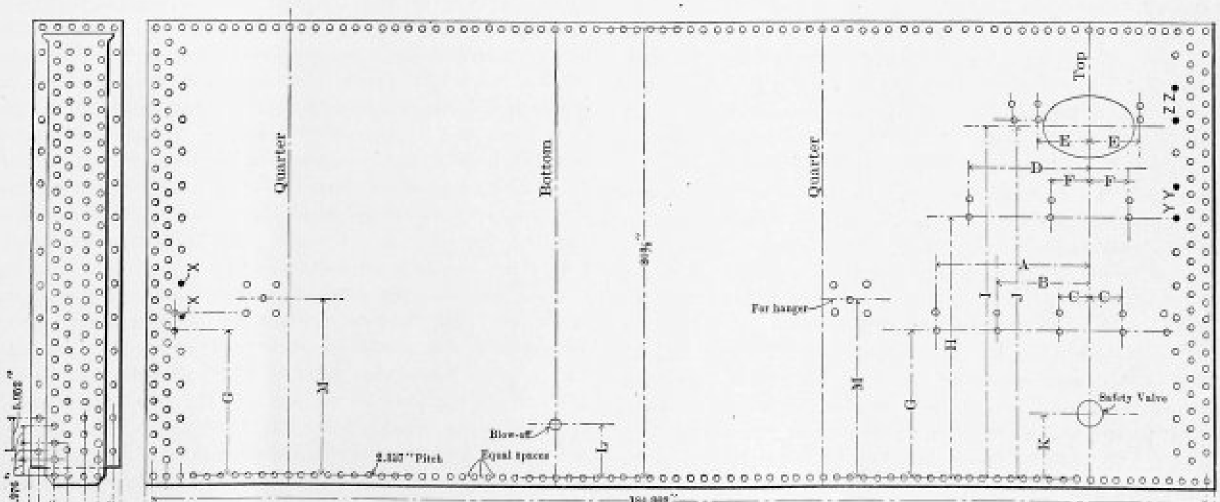


FIG. 52.—LAYOUT OF INSIDE COURSE OF SHELL, WITH LONGITUDINAL SEAMS FIGURED BY LIMITING RULE.

teen rivets. This makes seven rivets on each side. It is general practice to have an equal number in a bracket and this would require eight rivets. The adding of the extra rivet will, of course, increase the factor of safety.

THE COMPLETED BOILER.

In the preceding work one boiler has been worked out degree by degree, covering all the vital points of boiler construction for this class of boilers. More might have been written on each and every subject than has been presented, but as the subjects treated are part of the everyday work of a boiler maker, no one should experience a great deal of trouble in applying the rules which have been given to other sizes of boilers. Having figured the size and strength of all the different parts, we are now ready to lay out the completed boiler. Practical considerations will determine for any particular case which of the many possible forms of construction should be used for any individual part. It is sufficient that the boiler maker understands the advantages and disadvantages of the different forms of construction, and is able to figure the theoretical strength of each so that he may judge in a practical way which should be used. With this combination of theoretical and practical knowledge, as outlined in the preceding work, a boiler maker has taken a long step toward a thorough understanding of boiler making.

LAYOUT OF SHEETS, SHOWING METHOD OF LOCATING THE BRACES.

In Fig. 47 is the layout of the flues and the braces. The letters *A, B, C, D, E* and *F* represent the distances from the braces to the top center line of the boiler. Since these distances are measured along the arc, it will be noted that they are obtained by lines drawn from the center of the head to the shell, passing through the center of the braces.

In Figs. 51 and 52 we have the shell sheets as they appear in the flat. The center line of Figs. 51 and 52 is the top of the boiler, hence the distances *A, B, C, D, E* and *F* are the distances as taken from Fig. 47. The letters *G, H, I*, represent the lengths of the braces. Attention is directed to the rivets marked *X, Y* and *Z*. The location of the braces here coincides with the seam. The dotted rivet holes near the rivets marked *X X* indicate where the brace comes. As the seam will not permit of this location the brace is moved to one side. Some place the brace on the outer row of rivets, as shown in Figs. 51 and 52. Attention is also directed to the braces at *E*. In this case the length of the manhole makes it necessary to either shorten the braces or move them to one side. The dotted rivet holes indicate where they should come and the solid lines indicate where they are located.

The letters *M, O, J, P, L* and *K* represent the location of the hangers, brackets, blow-off, manhole and safety nozzle. The circumference, as explained, is generally figured from the mean diameter of the boiler, called the neutral diameter. It is the writer's practice to make a small allowance between the large and small sheets. After ascertaining the circumference of both courses, it has been my practice to make one course about 3-16 inch or ¼ inch shorter or longer than the difference found by figuring the circumferences from both mean diameters. This allowance is generally made, or taken off the small course, as in Fig. 52.

LONGITUDINAL SEAMS.

In Fig. 51 is shown the longitudinal seam worked out according to the practice of the Hartford Insurance Company. In Fig. 52 the longitudinal seam is worked out, the pitch being governed by the limiting rule as stated in previous work. The pitch as worked out by the former is 6.43 inches, which gives 85.4 efficiency (say 85 percent). The pitch as worked out by the limiting rule, as in Fig. 52, gives 5.952 inches with 84 percent efficiency. With the first rule we get a working pressure of 177 pounds, while with the latter we get only 175 pounds pressure.

In Fig. 49 is a detail of the longitudinal seam, shown in Fig. 52. Some question has arisen as to the distance from the circumferential seams to the first rivet. This distance is in this case 4.464 inches, while the length of the net section of plate is 5.592 inches. The arrows in Fig. 49 indicate the direction of force. Naturally the distance *A* is weaker than *B*, but in order to break the plate at *A*, it becomes necessary to shear the rivets in the circumferential seams as marked. Thus, the strength of the rivets of the circumferential seams adjoining *A* so assist *A* that it is not a weak place.

Fig. 48 represents the general make-up of the boiler, showing general layout of these parts as indicated in Figs. 51 and 52. In this view two end to end braces are shown. Fig. 50, showing a view of the rear head, with double angles. As already pointed out, welded braces are allowed 6,000 pounds per square inch of sectional area. Therefore, the area under the flues that will be subjected to pressure, multiplied by the pressure, will give the total pounds pressure to be provided for, the rivets in Fig. 50 being in tension. The manner of figuring the braces, brace pins, angles and rivets having been fully brought out in previous work, there is no need of taking this up further. Thus, the blank spaces of the diameter, area and value of the pins will depend upon the area and the pressure.

Arch Tubes and Brick Arches.*

BY G. W. BENNETT.

From a test which was recently made with a wide fire-box type of boiler to ascertain the efficiency of the brick arch and arch tubes the following results were obtained:

In a boiler equipped with four water bars 3 inches diameter, 458 tubes, 15 feet, 6 inches by 2 inches, fire box length 105 inches, with 75¼ inches, steam pressure 200 pounds, the evaporative power of the boiler is increased 14.9 percent by using the brick arch in the fire box. One-third of this increase is accredited to the water bars, while the remaining two-thirds of the increase must be due to the brick arch itself.

The reason for this increase is perhaps the storage of heat in the brick arch at an advantageous point, near the back flue sheet; the forcing of the path of the flame upward to the crown sheet and on through the upper flues, which form the best heating surface of the boiler, and the keeping clear of fuel of all the flues of the boiler. Without the brick arch, fuel is often thrown or carried by the draft into the lower flues, plugging them and thereby rendering these flues useless.

It is very noticeable that there is a saving to the flues caused by the brick arch; for, when the firebox doors are opened, the inrushing air must first come in contact with the hot arch and thereby become heated before reaching the flue sheet. No doubt, the brick arch causes also, a better intermingling of the gases and raises their temperature before they leave the firebox. Furthermore to evaporate the same quantity of water, over 14 percent less coal per square foot of grate surface per hour need be fired, thereby causing not only a saving of fuel, but also a saving in the work of the fireman.

From the table of "Results" and "Average Results," the following conclusions are drawn:

1. The equivalent evaporation per pound of dry coal, which is the most exact basis of comparison, is the number of pounds of water which would be made into steam at a pressure of 14.7 pounds per square inch by the heat from one pound of coal which contains no moisture, if the feed-water had been applied to the boiler at 212 degrees Fahrenheit. This term, then, gives a comparison of the three different arrangements—with the brick arch and water bars—with water bars, but without the brick arch—and without the brick arch and without water bars—all under the same conditions of feed water temperature, boiler pressure and coal analysis.

*Paper presented at the Master Boiler Makers' Convention, May, 1907.

With the brick arch and water bars, the equivalent evaporation per pound of dry coal shows a gain or increase of 14.9 percent over the arrangement without the brick arch and without water bars, and a gain of 9.3 percent over that arrangement without the brick arch, but with water bars. Therefore, the increased circulation and heating surface due to the water bars causes a gain of one-third of the 14 percent increase, while the brick arch must be accredited with the remaining two-thirds of that increase.

2. The actual evaporation per pound of coal is the result derived from dividing the total pounds of water evaporated by the total pounds of coal fired.

With the brick arch and water bars, the actual evaporation per pound of coal shows a gain of 13.1 percent over the arrangement without the brick arch and without water bars and a gain of 8.4 percent over the arrangement without the brick arch, but with water bars.

3. The equivalent evaporation per pound of coal is the result obtained by dividing the total pounds of water evaporated by the total pounds of coal fired and multiplying this quotient by the factor of evaporation, which factor is gotten from Steam Tables and which depends upon the steam pressure and the temperature of the feed water.

With the brick arch and with water bars, the equivalent evaporation per pound of coal shows a gain of 12.9 percent over the arrangement without the brick arch and without water bars, and a gain of 8.8 percent over the arrangement without the brick arch, but with water bars.

4. The coal fired per square foot of grate surface per hour is obtained by dividing the total coal fired by the number of square feet of grate surface and dividing again by the duration of the run or test in hours.

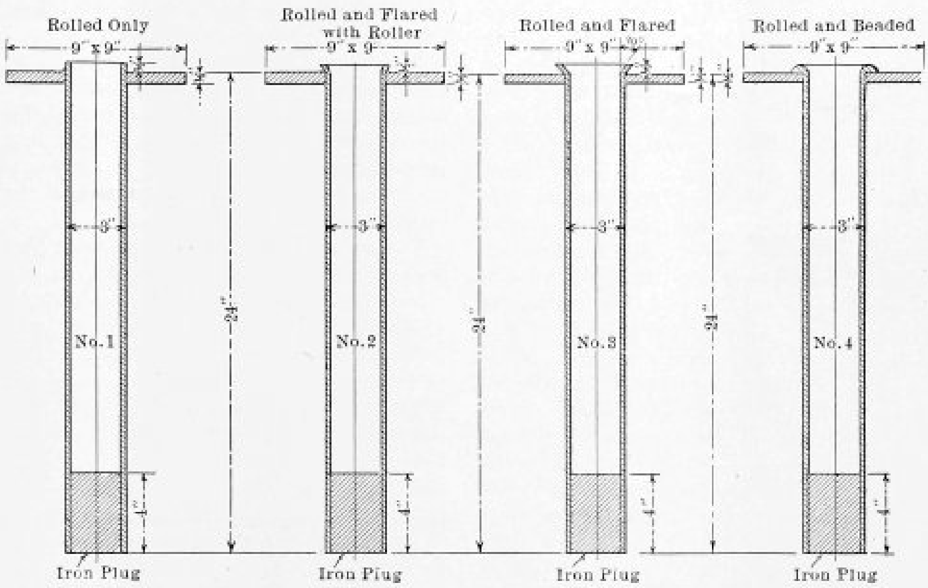
With the brick arch and with water bars, the coal fired per square foot of grate surface per hour is 14.7 percent less than with the arrangement without the brick arch and without water bars and 7.8 percent less than with the arrangement without the brick arch, but with water bars.

DESCRIPTION OF THE TEST.

The object of the test was to determine whether or not the brick arch increases the efficiency of the boiler; in other words, to compare the evaporative power of the boiler when equipped with the brick arch and when the brick arch is absent.

Since the water bars which were four in number, increase the heating surface and, also, the circulation of the water in the boiler, it was decided to make three divisions of the test: with the brick arch and with the water bars; with the water bars, but without the brick arch; and without the brick arch and without the water bars. The second division "with water bars, but without the brick arch" was made to determine the influence of the water bars upon the operative power. For every one of the three divisions, three runs were made upon the "Light Throttle" and three upon the "Wide Throttle."

In order to determine the amount of water evaporated, the tank, or water space in the tender, was calibrated for every half inch of depth of water. To insure no change of position of the tender it was raised upon screw jacks, until the springs were relieved of the load. By means of a glass water column or gage, which had been fitted to the tank, the water levels were read. Having first filled the tank, the water was permitted to run from the tank into a barrel, which rested upon a scale. The scale, having been adjusted to read zero with the barrel upon it, the weight of water between each half inch level of the surface was read directly from the poise. The water glass scale was graduated to tenths of an inch; the maximum error introduced by the misreading of one tenth is less than four tenths of one percent.



TEST SPECIMENS USED TO DETERMINE THE HOLDING POWER OF ARCH TUBES.

The coal, fired, was weighed as it was wheeled from the coal car to the tender. A separate compartment was built in the coal pit to hold unweighed coal to be used for banking over the fire and for firing up in preparation for a run.

The feed-water temperature was taken by means of a Fahrenheit thermometer, kept well beneath the surface of the water in the tank.

The temperature of the smoke box gases was taken by means of a Centigrade thermometer, graduated to 550 degrees, inserted in a brass oil well, which was located on the horizontal diameter at a point midway between the flue sheet and the baffle plate and which extended from the outside half to the center of the smoke box.

Four manometers or draft gages were used to determine the drafts in the smoke box, fire box and ash pan. The connections for the two manometers for the smoke box were located at points about half the height of the smoke box; one behind the baffle plate and midway between the baffle plate and the flue sheet, the other in front of the baffle plate at a point half way from that plate to the front end. Both of these connections extended into the smoke box a distance of one-fourth of its diameter. The connection for the fire box manometer was located at a point about twelve inches above the fire and midway the length of the fire box. The connection for the ash pan manometer was located at the center longitudinally and on a line with the dampers.

The main valves were removed, leaving only the valve stems in place.

By means of a trial run, the two notches, upon which the throttle lever would be placed for subsequent runs, were determined and marked. These two notches were decided upon: partly, by the amount of water that we could safely take from the tank for the run and yet not cut short the length of the run: and, partly, by the ability of the fireman to fire the required amount of coal.

In preparing for each run, after adjusting all manometers to read correctly, weighing in sufficient coal for the run, filling the tank with water and placing the thermometers in position, we then fired up with the unweighed coal until the fire became uniform, the steam pressure constant at 200 pounds and the water level in the boiler was brought to the proper height. Then, at a known signal, with all preparations made, firing from the weighed coal was commenced, the water level in the boiler was marked, the water level in the tank was read and the time was noted. Readings of the manometers, boiler pressures, temperatures and water level of the tank, were taken every ten minutes during the run. In order that the manometer readings might be more constant, these were noted for a period of one minute, during which time the fire box doors were not opened. The overflow from the injectors was caught and weighed and that weight deducted from the weight of water taken from the tank. During the run, no more coal was fired than was necessary to maintain a steam pressure of 200 pounds, the pop valves being set at 205 pounds, and for all runs the thickness of the fires was kept as constant as the eye could measure. At the end of the run, the water level was carefully kept at the level at which the run was commenced, the fire was kept, as nearly as possible, of the same thickness as at the start and the water level in the tank was carefully read.

In all our narrow fire box boilers the brick arch is held in position by studs, and in the wide fire box boiler the brick arch is supported by four 3-inch arch tubes, and to ascertain the holding strength of same when applied in different ways, the following test was made:

Eight test pieces were prepared in accordance with the accompanying illustration, each specimen having fitted in the lower end a four inch wrought iron plug in order to prevent the tube from collapsing when held in the jaws of the testing machine. The upper end of each specimen was held in position in the machine by means of a plate to which it was applied with roller expander, the same as when applying arch tubes in a boiler.

Test Piece	Tensile Strength
Rolled No. 1	12,000 lbs.
Rolled No. 2	13,000 lbs.
Average	12,500 lbs.
Rolled and flared 1/16-inch No. 1	23,500 lbs.
Rolled and flared 1/16-inch No. 2	23,800 lbs.
Average	23,650 lbs.
Rolled and flared 30 degrees No. 1	44,000 lbs.
Rolled and flared .30 degrees No. 2	41,500 lbs.
Average	42,750 lbs.
Rolled and beaded No. 1	48,500 lbs.
Rolled and beaded No. 2	42,700 lbs.
Average	45,600 lbs.

TEST OF THE WADE NICHOLSON HOLLOW ARCH ON THE NEW YORK CENTRAL R.R.

From a test which we are making at the present time on the New York Central, with the Wade Nicholson hollow arch, the following results were obtained:

For durability, Engine No. 3,931 ran 53 days, Engine No. 3,964 has now completed 62 days and the arch is still in good condition. Engine No. 3,913 had a good arch but it was removed to inspect the condition of the flues and the shell of the boiler. We found that there were 36 flues plugged in this engine and no leaks. Nothing has been done to her during this test.

The air passages through the brick have been open in all cases. The flues are better protected by having hot air pass through when the engine is standing or not working steam. We advocate as tight a door on the furnace as possible, so the draft from the air pump when the engine is not working steam will pump only air through the arch, the arch, of course, heating the air in the passage.

We find that the arch will stand a great deal of water thrown on it. Engine 3,898 has a side sheet that leaks almost constantly. Engine 3,894 had her arch cooled with hose in order to let a boiler maker do a quick job on her flues fourteen times in three weeks.

The engines are all good steamers. They require a lighter fire than with the common arch, as so much air is delivered on top of the fire that less air is passed through the fire, consequently the fire is fanned rather than torn and the smoke is almost entirely consumed. Less trouble of flue stopping is directly accountable for this fanning of the fire with the use of this arch.

The weight of this arch on the water bars is estimated 1,100 pounds, while that of the common arch is 1,450 pounds.

It is possible to repair a defective brick in the Wade Nicholson Arch. Uneven water bars do not effect the building up of the arch securely and the arch can be put in in from fifteen to twenty minutes complete.

To determine the saving of fuel, which all agree amounts to considerable, a test must be made, but they are too busy on this road just now to undertake that.

Rules and Regulations Prescribed by the British Board of Trade for the Inspection and Construction of Steam Boilers.

(Continued from June issue.)

Zig-zag riveted joints, Figs. 16, 17, 18, 20:

$$\sqrt{(\tfrac{11}{20}p + d)\ (\tfrac{1}{20}p + d)} = V.$$

Diagonal pitch, Figs. 16, 17, 18, 20:

$$\tfrac{3}{10}p + d = P_D.$$

For joint *J* (Fig. 18):

$$\sqrt{\frac{(11\,p + 8d)\ (p + 8d)}{20}} = V_1.$$

Diagonal pitch (Fig. 18):

$$\frac{3p + 4d}{10} = P_D.$$

To Determine the Working Pressure.

$$\frac{S \times \% \times 2T}{F \times D} = B.$$

Maximum Pitches for Riveted Joints.

T = thickness of plate in inches.

p = maximum pitch of rivets in inches, provided it does not exceed 10 inches.

C = constant applicable from the following table.

Number of Rivets in one Pitch.	Constants for Lap Joints.	Constants for Double Butt Strap Joints.
1	1.31	1.75
2	2.62	3.50
3	3.47	4.63
4	4.14	5.52
5	....	6.00

$$(C \times T) + 1\tfrac{5}{8} = p.$$

When the work is first class, such pitches may be adopted so far as safety is concerned, yet, in some cases, it may be well not to adopt the greatest pitch found by the formula. The maximum pitch should not, however, exceed 10 inches with the thickest plates for boiler shells. If, in any case, the pitch is found to exceed that arrived at by the foregoing formula, for the particular description of joint and thickness of plate, such pitches should not be passed, but all such cases should be reported.

Riveting.—The strength of ordinary joints is found by the following method:

$$\frac{(\text{Pitch} - \text{Diameter of rivet}) \times 100}{\text{Pitch.}} =$$

Percentage of strength of plate at joint as compared with the solid plate.

$$\frac{(\text{Area of rivet} \times \text{No. of rows of rivets}) \times 100}{\text{Pitch} \times \text{thickness of plate.}} =$$

Percentage of strength of rivets as compared with the solid plate.*

Taking iron as equal to 47,000 pounds per square inch and using the smaller of the two percentages as the strength of the joint and adopting the factor of safety as found from the preceding scale, then:

$$\frac{47{,}000 \times \text{least \% strength of joint} \times 2 \times \text{plate thickness in ins.}}{\text{Inside dia. of boiler in ins.} \times \text{factor of safety} \times 100.} =$$

Pressure to be allowed per square inch on the safety valves.

In the case of ordinary zigzag riveting the strength through the plate diagonally between the rivets is equal to that horizontally between the rivets, when diagonal pitch = .6 horizontal pitch + .4 diameter of rivet.

Plates that are drilled in place should be taken apart and the burr taken off, and the holes slightly countersunk from the outside.

The diameter of the rivets should in no case be less than the thickness of the plates of which the shell is made, but it will be found when the plates are thin, or when lap-joints or single-butt straps are adopted, that the diameter of the rivets should be in excess of the thickness of the plates.

When single butt straps are used they should be one-eighth thicker than the plates they cover.

Butt Straps.—Butt straps should be cut from plates and not from bars, and should be of as good a quality as the shell-plates, and those for the longitudinal seams should be cut across the fiber. When the straps are drilled in place they should be taken apart, the burr taken off, and the holes slightly countersunk from the outside.

Stays for Dished Ends.—Dished ends, unless of the thickness required for a flat end, should be stayed; but when they are equal to the pressure needed, when considered as portions of spheres, the stays, when solid, may have a stress of 14,000 pounds per square inch of net section, but the stress should not exceed 10,000 pounds when the stays have been welded, and such stays should be properly distributed. If dished ends are not equal to the pressure needed when considered as portions of spheres they should be stayed as flat surfaces.

Hemispherical ends subjected to internal pressure may be allowed double the pressure that is suitable for a cylinder of the same diameter and thickness. The ends should be formed of not less than four pieces.

Manholes, Doors and Domes.—Compensating rings of at least the same effective sectional area as the plate cut out, should be fitted round all manholes and openings, and in no case should the rings be less in thickness than the plates to which they are attached. The openings in the shells of cylindrical boilers should have their shorter axes placed longitudinally. It is very desirable that the compensating rings round openings in flat surfaces should be made of angle or T-iron. Cast iron doors should not be passed.

The neutral part of the boiler shells under steam domes should be efficiently stiffened and stayed, as serious accidents have arisen from the want of such precautions.

Hydraulic Test.—The boilers should be tested by hydraulic pressure to twice the working pressure in the presence, and to the satisfaction, of the Board's surveyors.

Circular Furnaces.—Circular furnaces with the longitudinal joints welded or made with single-butt straps double riveted, or double-butt straps single riveted:

$$\frac{90{,}000 \times \text{the square of the thickness of the plate in inches}}{(\text{length in feet} + 1) \times \text{diameter in inches.}}$$

= working pressure per square inch, provided it does *not* exceed that found by the following formulæ:

$$\frac{9{,}000 \times \text{thickness in inches}}{\text{diameter in inches.}} = \text{working pressure per square in.}$$

The second formula limits the crushing stress on the material to 4,500 pounds per square inch.

The length is to be measured between the rings if the furnace is made with rings.

If the longitudinal joints instead of being butted are lap-jointed in the ordinary way and double riveted, then 75,000 should be used instead of 90,000, but where the lap is beveled and so made as to give the flues the form of a *true* circle, then 80,000 may be used.

When the material or the workmanship is not of the best quality, the constants given above should be reduced, that is to say, the 90,000 may become 80,000, the 80,000 may become 70,000, the 70 000 may become 60,000; when the material and the workmanship are not of the best quality, such constants may require to be further reduced, according to circumstances and the judgment of the surveyor. Some of the conditions of best workmanship are that the rivet holes shall be drilled after the bending is done and when the plates are in place, and the plates afterwards taken apart, the burr on the holes taken off, and the holes slightly countersunk—sunk from the outside.

Cylindrical Superheaters.—The strength of the joints of cylindrical superheaters and the factor of safety are found in a similar manner as for cylindrical boilers and steam receivers, but instead of using 47,000 pounds as the tensile strength of iron 30,000 pounds is adopted, unless where the heat or flame impinges at, or nearly at, right angles to the plate, then 22,400 pounds is substituted.

When a superheater is constructed with a tube subject to external pressure the working pressure should be ascertained by the rules given for circular furnaces, but the constants should be reduced as 30 to 47.

In all cases the internal steam pipes should be so fitted that the steam in flowing to them will pass over all the plates which have steam in contact with them, and are exposed to the impact of heat or flame.

Superheaters should, as regards survey, be deemed to be the *most important parts* of the boilers, and must be inspected *inside and outside;* those that cannot be entered on account of their size or arrangement must have a sufficient number of doors through which a thorough inspection of the whole of the interior can be made.

Special attention should be paid to the survey of superheaters, as with high pressures the plates may become dangerously weak, and not give any sound to indicate their state when tested with a hammer; the plates should therefore be occasionally drilled.

Before commencing the survey it is prudent to question the engineer officers as to the tendency of the boilers to flame; if

* If the rivets are exposed to double shear, multiply the percentage as found by 1.75.

flaming is a frequent occurrence, extra care must be taken in the survey and in fixing the pressure to be allowed, as the tensile strength of the plate, when heated, is often reduced to a few tons per square inch. Drain pipes must in all cases be fitted to superheaters in which a collection of water in the bottom is possible.

Superheaters that can be shut off from the main boilers should be fitted with a parliamentary safety valve of sufficient size, but the least size passed without special written authority should be 3 inches diameter.

The flat ends, etc., of all boilers, as far as the steam space extends, and the ends of superheaters, should be fitted with shield or baffle plates where exposed to the hot gases in the uptake.

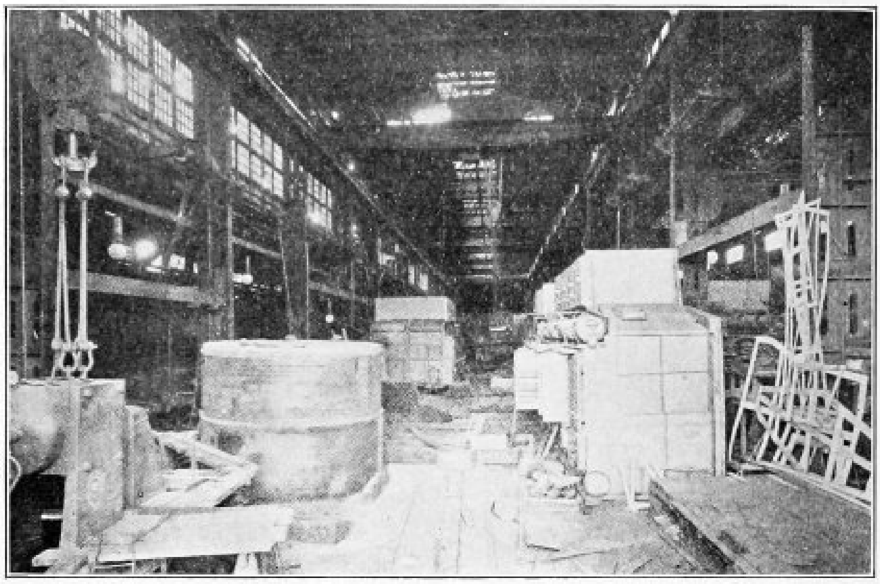
STEEL BOILERS.

Maker's Tests.—The following should guide the board's surveyors when the general quality of the steel has been found suitable for marine boilers:

The steel makers or boiler makers should test one or more strips or pieces cut from *each* plate for tensile strength and elongation, and stamp both results on each plate. When practicable the plates should be so stamped that the marks can be easily seen when the boiler is constructed.

Surveyor's Tests.—The surveyor is not obliged to witness the foregoing tests, although it is very desirable that he should when his other duties will allow him to do so, but he should see that all the plates are properly marked. He should, however, select of each thickness *at least* one in four of the plates to be used in the construction of the boiler and witness the testing by pulling and bending of at least one strip or piece cut from each selected plate, but when boiler plates exceed 15 feet in length, there should be a tensile test from each end and one bend test, and when they exceed 20 feet in length and at the same time exceed 6 feet in breadth, or exceed 2½ tons in weight, there should be a tensile test from each corner, and a bend test from each end. In the latter cases the testing of *each* plate should be witnessed by the surveyor. The mean of the results of the tests, if the latter fall within the board's requirement, as stated below, should be stamped on the plates. If a large number of failures take place in the 25 percent selected, the surveyor should select and see tested an additional number of plates, the number of additional tests being proportional to the number of failures. If for the plates from which the surveyor selects the above proportion, a greater stress is wished than is allowed for iron, tests for tensile strength and elongation should be made, also a few tempering and bending tests, and those for which no reduction of thickness is asked may be tested for resistance to bending and tempering only if preferred. In the latter case the tensile strength and elongation stamped on each plate should be reported by the surveyor to the Board of Trade, together with the results of the bending and tempering tests. From the plates, the tests of which have been made by the steel maker, and not witnessed by the surveyor, the surveyor may, if he thinks it advisable, select any plates after they are in the boiler yard and require specimens to be cut off and tested. If the results are not satisfactory the whole of the plates, except those which were tested and found satisfactory by the surveyor, may be liable to be rejected.

(*To be continued.*)



VIEW IN THE BOILER SHOP AT THE SHIPYARD OF JOHN BROWN & COMPANY, LTD.

The Boiler Shop at John Brown & Company's Clydebank Shipyard.

In 1899, John Brown & Company, Ltd., of Sheffield, England, long known as manufacturers of armor and large forgings of all sorts, acquired the Clydebank Shipyard, established in 1873. This yard covers an area of 80 acres, and is equipped with facilities for the construction of all types of ships from the smallest to the largest afloat. In such a place where everything from the keel plate to the mast head is made complete, the shops devoted to building the engines and boilers are necessarily the most up to date and complete which can be designed. The building in which the main boiler shops are located is 410 feet long and 120 feet wide. It is divided into three bays, in the two largest of which cylindrical boilers are constructed. There are several very powerful tools, notably plate-edge planers for dealing with plates 38 feet long, and a vertical machine for cutting ovals for manholes on cylindrical boilers. In the main bay there is a plate furnace 20 feet long by 10 feet wide, with a powerful steam hammer, the whole set being commanded by a hydraulic crane. There are several powerful flanging machines, multiple boring and drilling machines, vertical cold plate rolls, taking 12-foot plates, and many punching, shearing, drilling and tapping machines, besides several large riveting machines. The third bay is largely utilized for the construction and erection of water-tube boilers.

The water-tube boiler shop is situated on the ground floor of a two-story building immediately to the west of the main engine shop, and is exclusively devoted to the manufacture of the various parts of such boilers. The machines number in all about thirty, and comprise a three-spindle horizontal boring, facing and tapping machine, which finishes the end boxes into which the tubes are screwed; surfacing lathes for couplings, two milling machines, a number of emery grinders and a double-geared screwing machine. This latter consists of a large hollow spindle mounted on two long bearings, and carrying powerful universal self-centering chucks at each end, which grip the tubes to be screwed. The strong circular frame for holding the six dies employed is mounted on a saddle, and is fitted with micrometer cones for their adjustment. A slide rest is also provided for facing, beveling and grooving the ends of the tubes, and a centrifugal pump supplies the necessary lubricant to the dies while screw-cutting. The lower part of the shop is reserved for the building and testing of both steam generator and economizer elements.

Some Late Improvements on Compressive Riveters and Other Pneumatic Tools.*

BY CHESTER B. ALBREE,

President Chester B. Albree Iron Works Co., Allegheny, Pa.

COMPRESSIVE RIVETERS.

In comprehensive riveter work there are two or three types which are quite familiar, the oldest type being the straight hydraulic machine invented by Tweedel in England, and later on, the pneumatic riveter by Allen of New York, who was perhaps the first to make it a success. Later came the hydro-pneumatic riveters. With the hydro-pneumatic riveter we have been making some experiments, and it was found to be advisable for several reasons, notably for greater economy of air, simplicity of construction and better action, to try to improve the methods that had been in use. In driving rivets the pressure required differs from punching materials, in that in punching, your greatest pressure comes at the first of the stroke, when the punch comes down on the material. In riveting, however, especially hot riveting, the easiest work is when the die first strikes the rivet and the greatest pressure is required to finally form the head. That being the case, it can readily be perceived that a constantly increasing pressure would be the theoretically correct pressure to drive rivets. This pressure is most easily obtained by means of the toggle joint, which theoretically gives an infinite pressure with an infinitesimal movement at the end of the stroke. In practice, of course, we do not get an infinite pressure; but, as most riveters are of horseshoe or yoke type, the limit pressure is the yielding point or the bending point in the yoke. In straight toggle joint machines the general idea is shown in Fig. 1.

In practice we find that when the cylinder has made seven-eighths of its stroke the pressure line of the rivet dies rises up to about fifteen times the pressure in the cylinder. By that time we would have traveled within about 1-16 inch of the final stroke of the machine, and beyond that point the probabilities are that there would be spring in the yoke. If we made the yoke strong enough not to spring at all, it would be so heavy as to be utterly unmanageable. So it is only necessary that deflection should not occur at a pressure below that necessary to drive the rivet. Hence in the toggle joint arrangement we have the best possible arrangement for driving rivets.

But there are certain drawbacks in the practical application of the toggle pressure. The principal one is that its stroke is absolutely fixed. It never varies for a given leverage. In riveting, you are liable to have 1 inch or 2 inches, or maybe only ½ inch thickness of plate, and in order to have the maximum pressure just as the die comes to the surface of the plate, it is necessary to adjust the distance between the die and the point of maximum pressure by means of a screw actuated by hand. In work that does not vary it makes little difference, but in ordinary structural work, and boiler work, you have constantly to drive rivets through different thicknesses of material, and each time it will be necessary for the operator to adjust the screw. That requires a certain amount of skill, and if it is not done correctly the chances are that you will not drive the rivet sufficiently tight, if you do not close it with maximum pressure.

To overcome this difficulty of adjustment the hydro-pneumatic machine was devised, which is nothing more nor less than a hydraulic intensifier. The ram alone gives a very small but powerful motion, and it is necessary in riveting to have clearances, in order to go over angles, stiffeners, etc., so it is desirable to have a longer stroke. Of course we do not need high pressure over a longer distance than, say 1¾ inches. The question was then how to get a clearance movement. This was accomplished by putting a little extra cylinder below the air cylinder. The air pressure acting on its piston forces liquid into the ram cylinder at low pressure, and by this means we get 3 or 4 inches of preliminary adjustment.

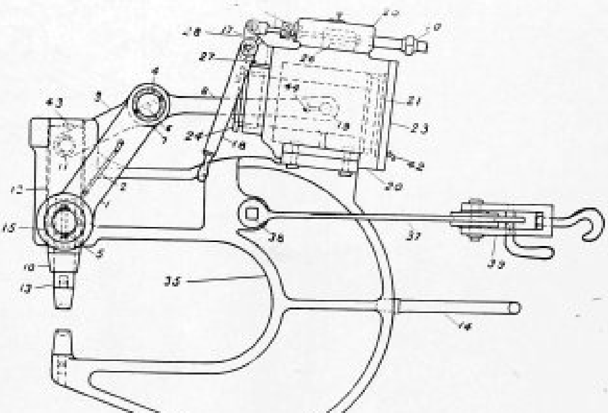


FIG. 1.

The objections to this form are in the first place: that it is very difficult to pack; and second, that in order to get two inches of die motion with a maximum pressure of 50 tons, it requires a 15 to 20-inch stroke in the air cylinder, and a very high pressure throughout this stroke in the ram cylinder and plunger cylinder; sufficient for the final closing pressure, thus wasting power. The practical advantage is that it does not require skilled workmen to adjust the dies; they adjust themselves. It occurred to us that we might get the desired toggle joint effect and yet have an automatic adjustment, and what I want to speak of is the device for the accomplishment of this, which may be of interest to you.

In Fig. 2 is shown our first attempt and also our perfected form. As far as the toggle joint action goes, it is practically the same as the first machine described. The pressure from the toggle, in the first form machine, is transmitted from the large area of the plunger to the top of the ram and also through a pipe to the adjusting cylinder. The ram being smaller in area and free to move, advances more rapidly than the plunger and continues until the rivet die on its extension strikes the projecting rivet. As the plunger continues, the pressure in the cylinder is limited by the pressure due to the spring in the adjusting cylinder, which is only 20 pounds per

*From a paper presented before the Engineers' Society of Western Pennsylvania.

square inch, insufficient to upset the rivet beneath the ram. Hence the liquid will now displace the piston in the adjusting cylinder, the ram remaining stationary. As soon, however, as the projection on the plunger enters the ram cylinder the full toggle pressure is transmitted through the incompressible liquid to the ram, forcing down the rivet, and the differential area above forces the remaining liquid in the large plunger bore into the adjusting cylinder.

During the downward motion of the ram the liquid beneath it is forced into the opposite end of the adjusting cylinder; against the spring pressure. It is obvious that the ram may move its whole adjusting stroke, or none at all, up to the time that the projection on the plunger enters the smaller area; after which the further travel of the ram is that of the plunger until the ram meets opposition greater than the pressure of the toggle, when it will stop. This arrangement, therefore, automatically adjusts the point of maximum pressure to suit the work. On the return stroke we have the direct pressure beneath the ram, as well as the suction of the plunger, to raise the ram to its original position.

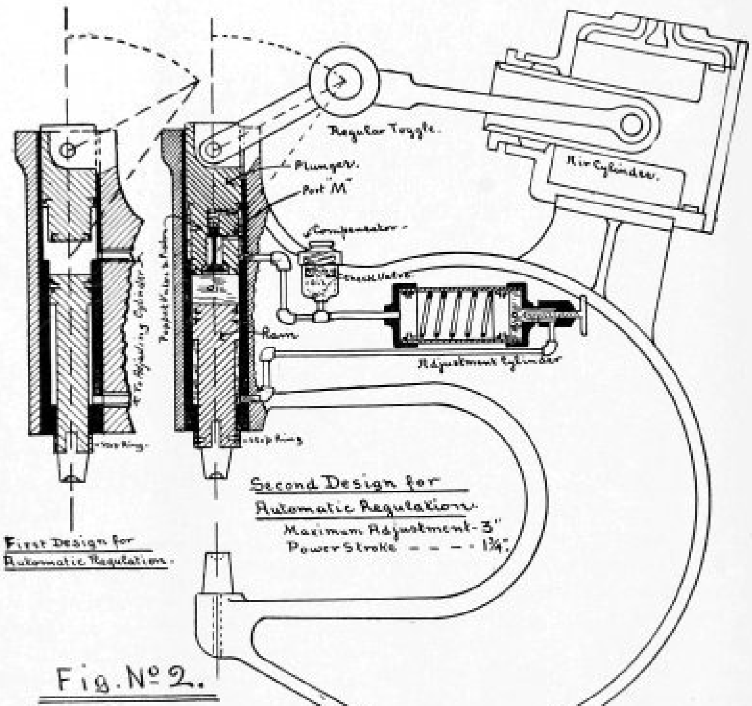


Fig. No 2.

Theoretically this design was correct, and it worked very well indeed for about two strokes. At the end of the second or third stroke our packing was gone and we have found it impossible to hold the pressures. The trouble lay in the fact that we put cup leathers at the end of the plunger, and when the cup leathers entered the chamber, the moment the pressure rose to a high point it tended to cut the leather right out. So in order to make the device practically, as well as theoretically successful, it was necessary to devise some scheme to have the leather cups, which hold better than any other hydraulic packing, move always surrounded by the walls of the cylinders, and pass no ports whatever. To do this and yet allow the liquid to pass freely from the upper to the lower part was rather a difficult proposition. We accomplished it in this manner.

Referring to the later form in Fig. 2 it will be noted that the extension of the plunger, when fully up, projects into the smaller area of the ram cylinder, and that cup leathers are used to pack it. In the interior of this extension is a valve of the poppet type, but having a stem carrying on its end a small piston. This valve is normally held open by a spring. So long as the pressure above and below this small piston is the same, the spring holds the valve open, but when the pressure below is greater than above the piston will move up, closing the poppet valve. This occurs only when the port *M* leading into the space below the small piston is closed, due to its passing from the large diameter bore to the smaller ram bore. When closed, the toggle pressure acts on the liquid below the plunger extension, raising the pressure sufficiently to move the small piston and connected valve, and later exerting very high pressure on the poppet valve, shutting it perfectly tight. The adjusting action is precisely the same as in the first type, except that the liquid flows through the plunger extension instead of around it, during the adjustment part of the stroke. With this arrangement it will be noticed that all of the plunger and ram packings are continually enclosed by cylinder walls and pass no ports or openings, so that the packing leathers are not injured. I would say that the adjusting device is patented and the poppet valve device is now being patented.

In any device of this kind there is always a certain loss of liquid due to a film in the ram (although theoretically the quantity of liquid is constant) and in the course of a little while there would be a partial vacuum inside and pressure on a cavity would not give good hydraulic pressure on the rivet. It was therefore necessary to provide a constant source of supply of the liquid, so arranged that when the pressure rose in the confined liquid it would not blow out, but when there was a vacuum in the system additional liquid would run in.

This loss of liquid is made up from a small storage, or compensating cylinder, full of liquid, having a piston with a spring behind it, connected to the larger bore of the plunger by a pipe having a check valve in it. Whenever there is pressure in the plunger cylinder the check valve remains closed; but when the toggle is fully back, and the piston in the adjusting cylinder is against its cylinder head, so that no pressure due to its spring is exerted on the liquid, any loss of liquid will tend to create a vacuum in the plunger cylinder, and then the check valve will open and oil flow out of the compensating cylinder under the pressure of the spring acting in its piston, to replace that lost.

PNEUMATIC HAMMERS.

We have been working on pneumatic hammers and have now perfected a hammer one or two features of which are novel and of interest. In pneumatic hammers of nearly all makes, one of the sources of trouble has been that if the workman picked up the hammer and put his finger on the trigger when there was no chisel or rivet set in it, the piston would begin to reciprocate, not having any tool to strike at the lower end it would strike the cylinder head, and in a matter of a minute or two it would smash the piston or cylinder. About 75 or 80 percent of the breakages of pneumatic hammers are due to carelessness of the workmen in pressing on the trigger when there is no work to do. In other words, the little piston strikes the cylinder head with very disastrous results. We have devised a method of obviating this trouble that is very simple.

The admission port is located near, but not at the end, of the larger cylinder bore. When no tool is placed in the end of the hammer the lower end of the large piston diameter passes and closes the admission port, thus preventing air from acting upon the differential area to lift the piston. Any compressed air below the large diameter escapes by a small leakage port to the exhaust; and this leakage port is only open when the admission port is closed. In hammers actuated by valves exterior to the piston, it seems impossible to use this device, and attempts have been made to mechanically close such valves, but they do not appear to be very successful. The same effect is obtained, but at the expense and loss of air, when the leakage port is designed to open when the piston is at the extreme end of the stroke, but does not close the admission port. Patents are now pending for these improvements.

This simple device is very effective. We can pick up a tool and with 100 pounds air pressure in the pipe, put your finger on the button, open the throttle, and it does not start unless the tool is fully in place, whereas with all other tools that I know of, the moment you put your finger on the trigger it begins to work, and it is only a question of a few minutes until it is good for nothing.

A SPECIAL RIVETER.

I might speak of another machine that was built for some special work that has a feature of interest. The work to be done was the riveting of some concrete mixers, they being in the shape of two cones placed together. The problem was to reach into a very limited space and drive the rivets. They had been doing it by hand, and wanted something a little quicker than the pneumatic hammer and something that gave tighter rivets. They wanted a power machine. It was necessary to have a reach of some 50 inches and we had an extremely small opening. At the same time it was necessary to be able to adjust for different thicknesses of material, and to give what we call an alligator motion to the jaws of the machine. The ordinary riveter could not be used for this work.

To secure adjustment of the projecting alligator jaws of the machine, we inserted a screw carrying the trunions of the

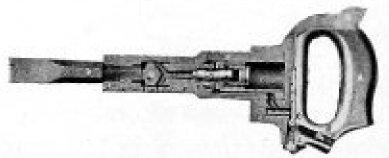


FIG. 3.—PNEUMATIC HAMMER.

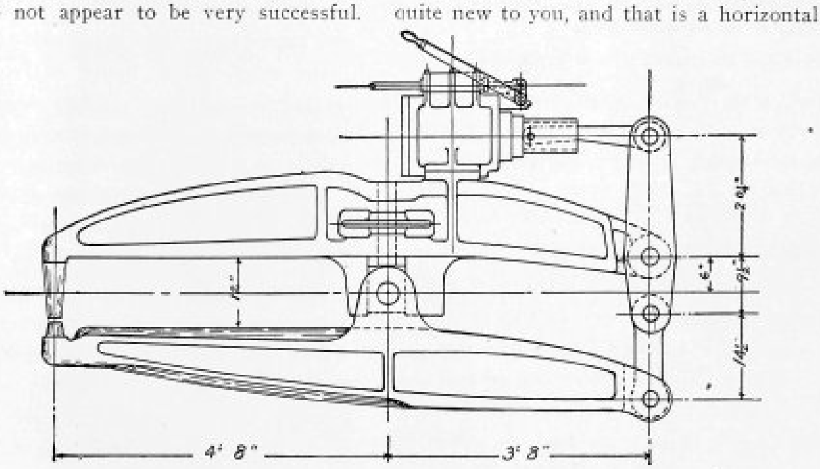
fulcrum on one end—a hand wheel, with thread in the hub, serves to raise or lower the screw—thus adjusting the distance between the ends of the jaws as desired, and at the same time not interfering with their clearance or action.

The details of the machine are plainly indicated in the cut—it is provided with a Universal bail, so that it can be used in any plane at any angle.

We also designed a special carriage to hold the double cones, rendering it unnecessary to raise either riveter or cones, but only to revolve the cones on their axis.

I might mention one other thing that I believe will not be quite new to you, and that is a horizontal method of riveting boilers. We made a wheeled truck carrying on its bed three sets of rollers running in the opposite direction. We suspended from a trestle a riveter large enough to do boiler work from a bail attached through a system of sheaves and tackles to a counterweight of one-fourth the weight of the riveter and having four times the travel. Then all that was necessary to do was to have a small chain block on the trestle to overcome friction of the sheaves and tackle. In that way we could raise this machine with a chain block for any diameter of boiler.

We have in very successful operation a machine with a 10-foot 6-inch gap, weighing about 25,000 pounds. We are now installing several other machines of this character, and it seems to be quite a feasible plan. It has several advantages over the ordinary Tower system. It takes up very much less room and the initial cost of installing the plant is very much smaller. This system requires no hoisting of the boiler, as it is simply rolled on the floor or on the rollers. Thus the power plant of the machine is limited to that necessary to actuate the toggle.



Alligator Riveter -
Fig-No 4.

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - New York

Christopher St., Finsbury Square, London, E. C.

H. L. ALDRICH, President and Treasurer

S. W. ANNESS, Vice-President E. L. SUMNER, Secretary

HOWARD H. BROWN, Editor

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico........	$1.00	.10
Other countries in Postal Union..........	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

Cleanliness in Modern Shops.

One of the most noticeable differences between a modern and an old-fashioned manufacturing plant is the amount of attention given in modern plants to the provision of clean wash rooms and lockers for the employees. More attention is paid to this in other lines of manufacture perhaps than in boiler making. On the other hand, there is no trade in which the workman must of necessity get so dirty as in boiler making. No man can expect to work all day with steel and keep clean. That, however, is no reason why he should not have a suitable place in which to wash up after the day's work is done, and a safe place in which to keep his overalls, or working clothes, without danger of having them stolen. The conditions in this respect are invariably worse in those contract boiler shops, which have been established for a number of years, because in the early days of boiler making the class of workmen employed was such that any provision of this sort would not only have been undesired but not even appreciated. The day of the burly, hard-drinking, rough type of iron worker is, however, past, and in his place has come a force of skilled mechanics, whose duties do not require such hard manual labor but call for a higher order of intelligence, in order to operate the powerful machinery which is used to-day in boiler making. Most railroad companies recognize this fact, and when erecting new shops make suitable provision for the needs of their employees. The contract men have an equal responsibility and should not fail to fulfil it. As this is a question which bears only indirectly on the productive power of a plant, it is apt to receive far less consideration than its importance demands.

The British Board of Trade.

The British Board of Trade is best known to boiler makers in this country through the rules and regulations which it prescribes for the construction and inspection of steam boilers. While these rules are now being published in our columns nothing has as yet been said regarding the origin of this Board, its usefulness, or the authority with which it is invested. It should not be inferred from the name that it is an organization in any way similar to what is known as a Board of Trade or Chamber of Commerce in the large cities of this and other countries. It is entirely different from these, for it is a well established branch of the British government, divided into departments for the purpose of carrying out various acts of parliament. Its president usually has a seat in the Cabinet, and is practically a Secretary of State for Trade, while in 1867 its vice president became a Parliamentary Secretary, whose duties were similar to those of an Under Secretary of State. Among the many departments into which the work of the Board has been divided are the Railway, Marine, Harbor and Finance, Commercial, Labor and Statistical, the duties of each of these departments having been increased and extended to cover an enormous amount of detail.

The origin of the Board of Trade may be traced back as far as the fourteenth century when councils and committees were formed to advise parliament in matters of trade. In the middle of the seventeenth century under the Commonwealth, a department of a permanent character was formed for this work and Cromwell's policy was continued under the Restoration. A committee of the Privy Council was appointed in 1660 for the purpose of obtaining information regarding imports and exports and to improve trade. A few years later still another committee was appointed to act between the Crown and the foreign plantations or colonies. These two committees were united and given the name which has lasted to the present day "The Board of Trade and Foreign Plantations." This Board was abolished and revived again once or twice during the next century, the last time being when Burke made his strong fight upon public offices in 1780. Six years after this happened another permanent committee of the Privy Council was formed by order of the Council and, with one or two exceptions, the legal constitution of the Board of Trade is still regulated by that order. The duties of the Board then increased so rapidly that it was subdivided into departments and allowed to expand to its present responsible position.

The Marine Department, which is the department responsible for the rules on boiler construction, was established in 1850 to carry out the various provisions of the merchant shipping act. These rules are, therefore, those prescribed by the British government for the construction of marine boilers, and have about the same jurisdiction as those prescribed by the United States Steamboat Inspection Service through the Department of Commerce and Labor. The British Board of Trade, in fact, resembles in a good many of the features of its work the Department of Commerce and Labor in this country.

TECHNICAL PUBLICATIONS.

Domestic Hot Water Apparatus, by Paul N. Hasluck. Size 5 × 7½ inches. Pages 160. Numerous engravings and diagrams. London, 1907. Published by Cassell & Co., Ltd., Price 2/-.

The writer of this book has gone very thoroughly into the work, dividing it into several sections, in order to more exhaustively explain it to the reader. Commencing on "Circulation in hot water systems," he proceeds to discuss the tank system, the cylinder system, and the combined cylinder and tank systems. Each of these systems is explained very clearly, and the numerous diagrams are self-explanatory. Various methods of making connections are shown and explained, and the best methods are, of course, pointed out.

Heating water indirectly, and heating water by steam are then described, and the working properties and calorifiers are made quite clear to the reader. The selection of back boilers for ranges forms a very interesting chapter, and this is a matter which will interest all heating engineers, for a number of sketches are given, illustrating the different styles at present in use. Pipes and pipe coverings are treated in a very lucid way, and the defects of various metals are noted.

Towel rails, radiators and other domestic heating matters are treated in a manner that shows the writer has a thorough grasp of his subject. The sketches throughout are good, and there is little doubt that the book will have a good sale.

COMMUNICATIONS.

The Safe Working Pressure of Boilers.

EDITOR THE BOILER MAKER:

I have noticed that more questions are asked regarding the above topic in the question and answer columns of engineering papers than on any other subject. This must be because engineers understand neither how to figure the safe working pressure of boilers, nor upon what the safe working pressure depends. The working strength of a cylindrical boiler depends upon the tensile strength and thickness of the plate and the diameter of the boiler.

The plates which are used in boiler construction are generally subjected to a tensile strength test in a suitable testing machine. This machine grips the ends of the piece to be tested and the pressure required to tear the piece apart is the tensile strength of the plate, the stress being registered in pounds. When we hear of a piece of boiler plate having a tensile strength of say 50,000 pounds it means that it would require 50,000 pounds to tear a piece of the material one inch square in two pieces. The reason that the tensile strength varies is due to the quality of the metal. For this reason it is important that the tensile strength be known in order to determine at what pressure the boiler can be operated. Of course, after a boiler is built and in service it is impossible for the engineer in charge to obtain a specimen of the plate for testing and so if he desires to figure out the strength of the boiler he must either depend upon information supplied by the builder or else use an average value for the strength of the boiler plate. An average value would be 50,000 pounds since boiler plate usually runs from 40,000 to 60,000 pounds tensile strength, and that is the figure usually taken when the actual tensile strength is not known. This may be taken as a safe basis to work upon, even though the real tensile strength of the plate has been reduced somewhat, because in figuring the safe working pressure a factor of safety is used which determines the margin of strength over and above the pressure which would be necessary to rupture the boiler shell.

The factor of safety depends upon several conditions; the quality of the material, the workmanship put into the construction of the boiler and the character of the seam, both as regards the method of making the holes, whether drilled or punched, and the method of riveting. The usual factor of safety allowed is 6 for the average type of boiler, which signifies that only one-sixth of the strength of the boiler is being used. In other words this means that if the boiler were carrying a pressure of 100 pounds to the square inch the bursting pressure would be 600 pounds. It is doubtless true that the factor of safety in a large number of boilers is below 6, when the character of construction and the age of the boiler are taken into consideration. In practice it would not be advisable to figure the strength of a boiler with a factor of safety of 6, if the age and general condition indicated that the boiler were deteriorating. Another matter which affects the safety factor is the thickness of the plate and the diameter of the boiler, as the thicker the plate and the smaller the diameter the greater the pressure the boiler will stand. For instance if two boilers were made of the same thickness of steel, but were of different diameters, the greater pressure could be safely carried on the smaller boiler, while on the other hand if the thickness of the plate were different, but the diameters were the same it is evident that the thicker plate would withstand the greater pressure

A good rule for determining the safe working pressure of a boiler constructed of iron and having the longitudinal seam double riveted is as follows:

$$\frac{t \times .70 \times T \times (1/6)}{R} = \text{the safe working pressure.}$$

In the above t = the thickness of the plate in inches.

.70 = the percentage of strength of the double riveted seam, as compared with the solid plate.

T = the tensile strength of the plates in pounds per square inch of section.

R = radius of the boiler in inches.

It will be seen that in this formula the factor of safety is 6, or only 1-6 of the tensile strength of the plate is used.

Using the above formula to prove the statement that the diameter affects the safe working pressure of a boiler we have the following: supposing that two boilers were 50 and 60 inches in diameter and constructed of ⅜-inch iron having a tensile strength of 60,000 pounds. In the case of the 50-inch boiler we have:

$$\frac{3/8 \times .70 \times 60{,}000\ (1/6)}{25} = 105 \text{ pounds, the safe pressure}$$

at which a 50-inch boiler can be operated.

In the case of a 60-inch boiler we have the following:

$$\frac{3/8 \times .70 \times 60{,}000\ (1/6)}{30} = 87 \text{ pounds,}$$

the safe working pressure of a 60-inch boiler.

In the above examples the longitudinal seams were figured as being double riveted. If they were single riveted the value of the percentage of strength would be about .56 instead of .70. Then the safe working pressure of a boiler of the above-mentioned construction, but single riveted, would be as follows:

$$\frac{3/8 \times .56 \times 60{,}000\ (1/6)}{25} = 84 \text{ pounds,}$$

the safe working pressure for a 50-inch boiler having single riveted longitudinal seams.

If the boiler were 60 inches in diameter and single riveted in its longitudinal seams the following would be the safe working pressure:

$$\frac{3/8 \times .56 \times 60{,}000\ (1/6)}{30} = 70 \text{ pounds, the}$$

safe working pressure.

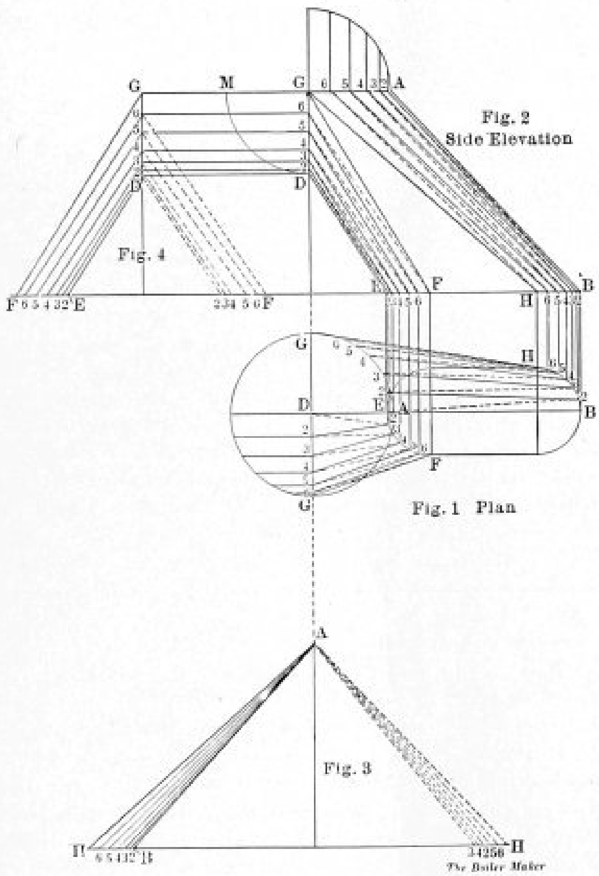
It should be remembered that these percentages of strength of boiler seams are not fixed quantities by any means, because they are governed by other factors. They are merely used as an average strength of the average seam, but are not correct in all cases. E. PRICE.

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.

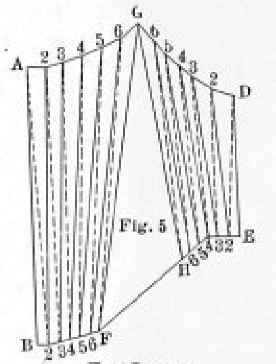
Q.—Will some of the readers of THE BOILER MAKER give in detail the layout of a Y breeching? TRAMS.

A. 1.—In the following method for laying out a Y-breeching, such as is shown in Fig. 6, the throat or section through the intersection of the two branch pipes is laid out in the form of a semi-circle. First draw the half plan, Fig. 1, and the half ele-



DETAILS OF SOLUTION BY J. C. PRESLAR.

vation, Fig. 2. Divide the quarter circle *AG* Fig. 1, into any number of equal parts and divide the quarter circles *EF* and *HB* into the same number of equal parts. With *G* Fig. 2 as a center and a radius *GD* draw the quarter circle *DM* and divide it into the same number of equal parts as the other quarter circles. Connect the corresponding points in the large and small circles, as shown, dividing the surface of the branch pipe into triangles. Project the points of division on the quarter circles in the plan to the side elevation and draw the side view of the lines which form the triangles. The true lengths of all the lines on the upper or right hand section of the branch pipe may be then found by laying off the height of the breeching from the base line to *A*, Fig. 3. Set off from the center line of this figure, on the horizontal line *H-H* the distances *G-H*, *H-6*, 6-6, 6-5, etc. as measured from the plan, Fig. 1. In order to avoid confusing the figure draw the solid lines on one



Half Pattern

side and the dotted lines on the other. The true length of the lines on the lower or throat section of the pipe may be found as indicated in Fig. 4. The height of each of these triangles is different and must be projected across from the points 2, 3, 4, 5, 6, in the throat, Fig. 2, while the base is measured from the plan Fig. 1, as before. These triangles are shown in Fig. 4.

To lay out the half pattern, draw any line as *A-B*, Fig. 5. Set the dividers to the distance *A-B*, Fig. 3, and lay this out on the line just drawn in Fig. 5. With the dividers set to the distance *B-2*, Fig. 1, describe an arc from the point *B*, Fig. 5, as a center. Set the trams to the dotted line *A-2*, Fig. 3, and from the point *A*, *Fig.* 5, as a center describe an arc intersecting the arc already drawn, locating the point 2. Set the dividers to the space *A-2*, Fig. 1, and draw an arc from the point *A*. Then set the trams to the solid line *A-2*, Fig. 3, and

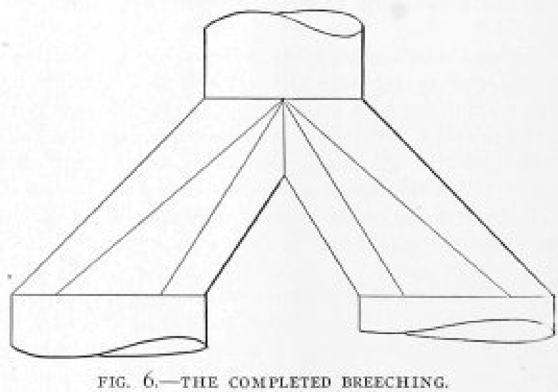


FIG. 6.—THE COMPLETED BREECHING.

from the point 2, Fig. 5, intersect the arc previously drawn from *A*, locating the point 2 in the upper edge of the pattern. Continue in a like manner until the line *G-F* has been drawn, then construct the remainder of the pattern by taking the length of the lines found in the triangles drawn in Fig. 4. The pattern thus found locates the rivet lines. The laps should be added to this.

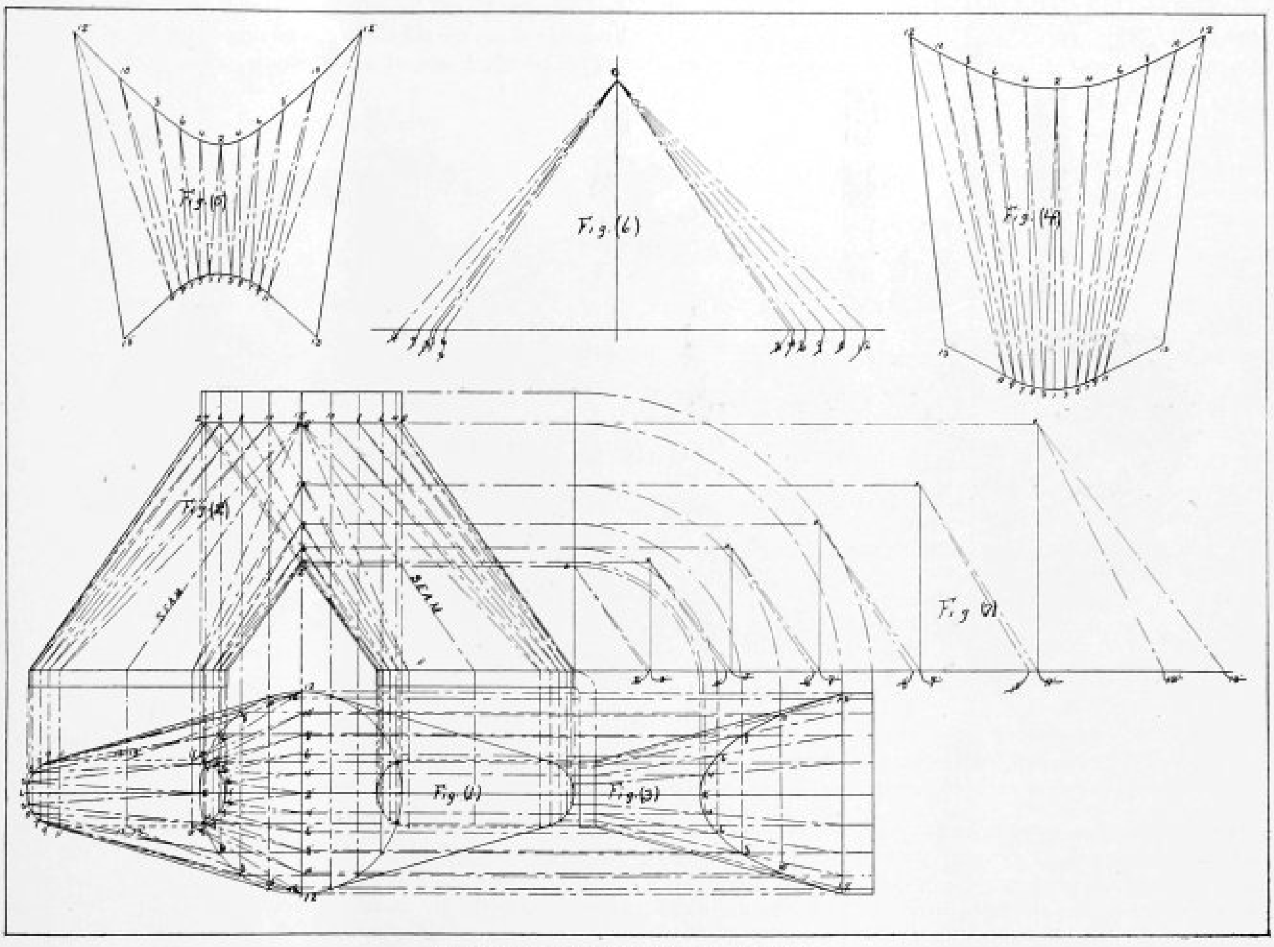
J. C. PRESLAR.

A. 2.—Let Fig. 1 represent the plan and Fig. 2 the side elevation of the breeching to be developed. Divide the large semi-circle, Fig. 1, into a number of equal parts and number them 2, 4, 6, 8, 10 and 12. Space the small semi-circle into the same number of equal parts, numbering the divisions on the outside semi-circle 1, 3, 5, 7, 9, 11 and 13, and on the inside circle 1', 3', 5', 7', 9', 11', 13'. Draw vertical lines from the points 2, 4, 6, 8, 10, 12, Fig. 1, until they intersect the line 2 — 2, Fig. 2. Also draw vertical lines from the points 1, 3, 5, 7, 9, 11, 13 and 1', 3', 5', 7', 9', 11', 13' until they meet the base line of the side elevation. Then draw lines from 1 to 2, 2 to 3, 3 to 4, 4 to 5, etc., and also from 1' to 2, 3' to 4, 5' to 6, etc., in both plan and elevation as shown. In the side elevation the points where these lines meet the vertical center line give us the heights for determining the line of intersection between the two branch pipes. Number these points 2', 4', 6', 8' etc., then draw the lines 2'-3', 4'-5', 6'-7', etc.

Having drawn these lines in both Figs. 1 and 2, it is now of the lines are to be found. The height of the triangles will be the height of the points 2', 4', 6', 8', 10', 12' respectively in the side elevation, Fig. 2, which may be projected across, as indicated at the points X.

Now to find the true length of the lines 1-2, 2-3, 3-4, 4-5, etc. on the upper half of the pipe draw Fig. 6, in which the height from the base line to O is the height of breeching. Lay off for the bases of the triangles the distances 1-2, 2-3, 3-4, etc., as measured from the plan, Fig. 1, placing half of them on either side of the figure in order to avoid confusion.

The patterns for the upper and lower sections in each pipe may now be drawn. The pattern for the upper part is shown at Fig. 4; and for the lower or throat section at Fig. 5. The line 1-2, Fig. 4, is made equal to the line 1-2 in the side eleva-



DETAILS OF SOLUTION BY J. E. LANDIS.

necessary to draw an end elevation locating these lines in that view. Draw lines horizontally from the points 2', 4', 6', 8', 10', 12', Fig. 2, and project them around to the end elevation, Fig. 3. The points where these projecting lines intersect the elementary lines having corresponding numbers give us the section through the throat. From the points thus found in the end elevation draw horizontal lines to intersect the vertical center line of the plan, Fig. 1, thus giving the true location of the points 2', 4', 6', 8', 10', 12'.

It is now possible to find the true length of all the lines which have been drawn on the surface of the connection. Take the distance from 1' to 2' in the plan, Fig. 1, and set it off as at 2', Fig. 7, then take the distance from 2' to 3' in the plan, Fig. 1, and set it off at 3', Fig. 7. Do the same with the other distances as from 3' to 4', 4' to 5', etc. These distances are bases of the triangles from which the true length tion, Fig. 2. With the trams set to the distance O-3, Fig. 6, strike an arc from the point 2, Fig. 4, as a center and from the point 1 space off the distance from 1 to 3, as measured in the plan, Fig. 1, the intersection of these two arcs locating the point 3. Next, with a radius equal to O-4, Fig. 6, strike an arc from the point 3, Fig. 4, as a center, and from point 2, Fig. 4, space off the distance measured from 2 to 4 in the plan, Fig. 1. The intersection of these two arcs locates the point 4. Proceed in a like manner to lay out points 6, 7, 8, 9, 10, 11, 12, 13.

To draw the pattern for the lower or throat section, draw the line 1'2', Fig. 5, equal to the line 1'2', Fig. 2. Then with a radius equal to X3', Fig. 7, strike an arc from the point 2', Fig. 5, as a center and from the point 1', Fig. 5, space off the distance 1' 3', as measured in the plan, Fig. 1, the intersection of these two arcs locating the point 3'. Proceed in a like manner to locate the points 4', 5', 6' and so on to 13'.

The proper allowances must be added to these patterns for laps and the take up in bending the material.

JOHN E. LANDIS.

Editor's Note.—The two methods described above for laying out a Y-breeching differ in that in the second method the line of intersection between the two branches of the Y was located by projection, while in the first method the throat was made in such shape that this line of intersection would be a semicircle. These two methods will, therefore, give breechings which have slightly different forms due to the difference in the throat.

Q.—How do you figure the strength of metal, both steel and cast iron, to reinforce a hole 11 by 16 inches cut in a ½-inch boiler head? Also, would the same rule answer for a hole cut in the shell? R. H. C.

A.—In figuring the strength of a reinforcing ring, it is customary to make the strength of the cross section of the ring equal to the strength of the cross section of the plate taken through the shorter diameter of the hole. Using the dimensions given above, the strength of the metal across the short diameter of the hole is 11 x ½ x 60,000, or 330,000 pounds. If a steel reinforcing ring is used, its tensile strength will be the same as that of the plate from which the hole is cut, and therefore it would only be necessary to make its sectional area equal to the sectional area cut from the plate, or 5.5 square inches. Assuming the thickness of the ring to be ¾ inch, this gives its width as $\frac{5.5}{.75} = 7.34''$. Since this is the total width of the ring, the width of the section on one side of the hole would be ½ of this plus the diameter of the rivet hole; or, using 1⅛-inch rivets, this would give the width of the ring as about 4⅞ inches. If the ring were to be of cast iron, which has a tensile strength of about one-third that of steel, it would be necessary to make the sectional area of the ring three times as large.

This rule would also apply to a hole cut in the shell if the shorter diameter of the hole were parallel to the longitudinal axis of the boiler, as it always should be.

ENGINEERING SPECIALTIES.

Franklin Air Compressors for the Pennsylvania Railroad.

Two Franklin air compressors of the type shown on this page, built by the Chicago Pneumatic Tool Company at their compressor works, Franklin, Pa., have been installed in the power plant of the new South Altoona foundry of the Pennsylvania Railroad. Each compressor has compound steam cylinders 12 and 21 inches diameter and two-stage air cylinders 19 and 11 inches diameter, all 24-inch stroke, designed for 100 pounds terminal air pressure with 125 pounds of steam at the throttle, and having a piston displacement of 985 cubic feet of free air per minute at 125 revolutions per minute. The steam and air cylinders are arranged tandem to each other. They are connected with heavy tie rods and are rigidly supported by a sole plate, the pillow blocks having extra broad pedestals.

The cylinders are of extra strong, close-grain iron, with appropriate thickness for reboring, and are fitted with heads which are carefully finished and interchangeable in the same sizes. The air cylinders and cylinder heads are thoroughly water jacketed, the cooling effect of the cold water being especially concentrated around the discharge valves, which naturally sustain the heat due to compression and friction that has not been eliminated by the water jacket during the actual process of compression. A novel feature, which is designed as a safeguard to prevent the possibility of serious accident through water entering the interior of the cylinder should the gasket between the cylinder and head become ineffective, is the outside water connection for conducting the circulation of water between the air cylinder and cylinder head.

The steam and air pistons are of the solid type, cored hollow, and are provided with snap rings of special iron carefully fitted to place. They have no followers or bolts, thus avoiding liability to accident.

The steam valves are Meyer adjustable cut-off valves, which have provisions for readjustment when required by wear. To meet the objections sometimes offered against a numerous complement of poppet valves, these compressors have been built with mechanically moved intake valves of semi-rotary Corliss type, placed in the cylinder heads and driven by gear

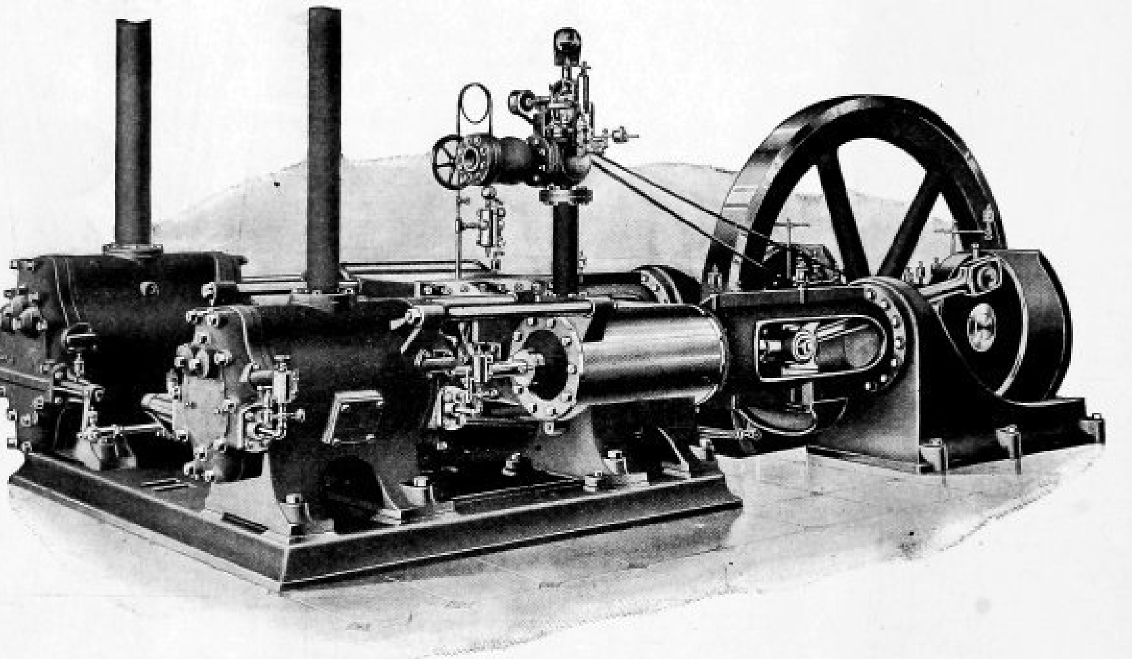
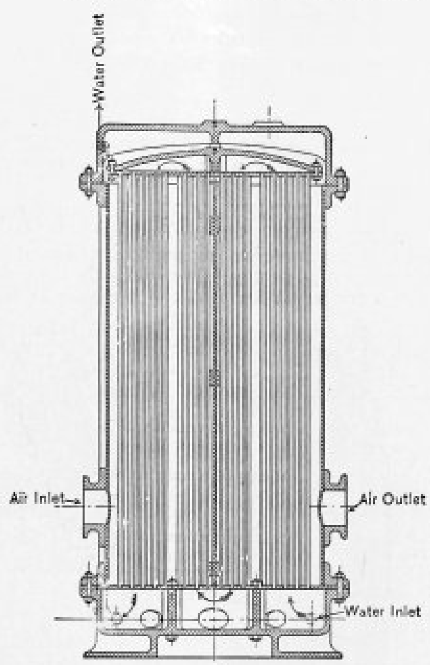


FIG. 1.—TWO-STAGE AIR COMPRESSORS WITH MECHANICALLY MOVED IN-TAKE VALVES FOR THE PENNSYLVANIA RAILROAD.

from eccentrics on the main shaft, as shown in Fig. 1. These positively moved valves combine exceptionally liberal area with short ports and minimum clearances. They open and close without impact, and are therefore free from hammering and wear incident to poppet valves. The motion to drive these Corliss intake valves is taken from the steam cut-off valve stem or rocker arm of the opposite side of the compressor, avoiding extra eccentrics and adding compactness. The valve gear details are of liberal proportion, and all bearings throughout the gear are provided with phosphor bronze bushings adjustable for wear. Inlet as well as discharge valves can be removed and inspected without disturbing the valve gear.

The air discharge valves are of poppet type, cup shaped, pressed from high grade steel and fitted with light tension

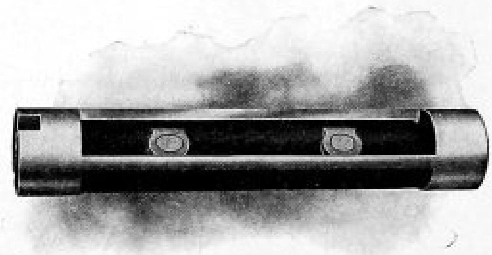


INTERCOOLER FOR ORIGINAL PATTERN TWO-STAGE COMPRESSOR.

springs. These valves also have removable seats and guides and are readily accessible for adjustment or repair. The cranks are of disc pattern, made from best quality charcoal iron. The shafts and crank pins are forced to their places, the former being keyed and the latter riveted. The connecting rods are from best forged steel, and the boxes are adjustable for wear in accord with the most approved practice.

The intercooler, which is separate from the compressor and may be placed where convenience dictates, is a most important feature. This consists of a steel shell containing a set of tubes, the tubes being fitted into the heads with provision for expansion and contraction. A constant circulation of cold water is maintained through the tubes and the compressed air from the initial compressing cylinder enters the intercooler on one side, passing to the next compressing stage. Adequate provision is made for readily cleaning the interior of the intercooler, and it is claimed that the tubes, being made of composition metal, do not rust or become foul.

The air passes in at opening marked "air inlet" and out at opposite side of shell marked "air outlet." A baffle plate is fixed in center of shell, extending from side to side and from the bottom tube sheet to within a few inches of the top tube sheet. Air entering from low-pressure cylinder is thus compelled to travel between the closely spaced brass tubes up over top of baffle plate and down through an equal number of tubes to the outlet, on its way to the high-pressure cylinder. The combined base and water head is divided into three compartments by cast iron partitions, and the upper water head into two compartments. The cooling water enters at the bottom and is compelled to traverse the entire length of the tubes four times before passing out, as indicated by arrows showing water circulation. A hand hole in each compartment of lower water head affords easy access for cleaning, and by removing upper heads the tubes are accessible for same purpose. A drain is furnished for each water compartment, and also one for drawing out water from the air chamber. The upper



water head has lugs cast on it, which fit inside the air head, preventing any strain on the tubes through the intercooler being laid on its side in shipment, at the same time leaving the water head free to move up and down to accommodate the expansion and contraction of the tubes.

The air governor has a connection to the air receiver and regulates the steam supply to the compressor to suit the air consumption, maintaining a constant unvaried air pressure, even though the demand be intermittent. Working in combination with this governor is a speed governor for regulating the speed of the engine

The Franklin air compressors are manufactured in more than one hundred sizes and styles, ranging in capacity from 30 to 5,000 cubic feet of free air per minute displacement, and suitable for a wide range of compressed air employment, in addition to the operation of pneumatic shop appliances.

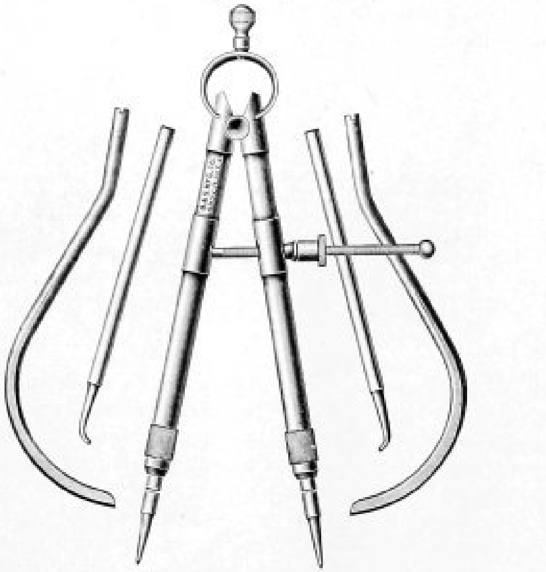
Ejectors as Liquid Elevators and Conveyors.

The ejector is a little machine whose large field of usefulness is just beginning to be appreciated by a great many users of steam. It is simple in construction, and it is claimed that far less steam is required for its operation than for that of a steam pump. On account of its compactness and portability it can be placed with little expense near the work to be done. For these reasons it is becoming a common substitute for steam pumps, syphons, etc. Some idea of its wide field of usefulness

may be gained when it is taken into consideration that its manufacturers claim that anything and everything in the way of liquid substances (if not too thick) can be transported from one level to another or horizontally any reasonable distance. It is largely used in such plants as breweries and chemical houses for handling heated liquids and also for raising liquids from wells, tanks, mines, vessel holds, docks, etc. Distilleries, creameries, tanneries, dye works, paper mills and similar plants also use them for syphon purposes. The machine of this type shown in the illustration is manufactured by the Penberthy Injector Company, Detroit, Mich.

A Combination Divider and Caliper.

Every layer-out appreciates the necessity of having an accurate pair of dividers, which can be delicately adjusted. In the dividers shown in the following illustration the arms or holders are provided with split chucks to receive the points, which are held firmly by a single turn of the knurled nut that closes the chuck concentrically. A pencil, or, as shown in the



illustration, either inside or outside caliper legs may be substituted for the divider points, thus increasing the usefulness of the tool. It is of steel carefully finished with all sharp corners practically eliminated, and will describe a circle 21½ inches in diameter. The Brown & Sharpe Manufacturing Company, Providence, R. I., are the manufacturers.

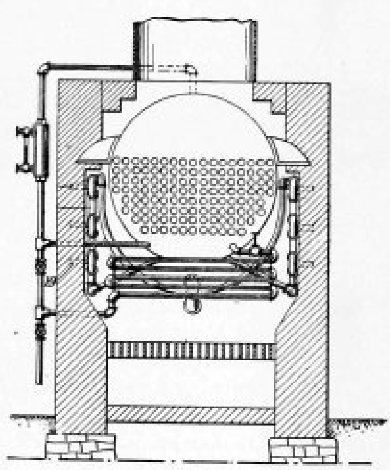
SELECTED BOILER PATENTS.

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.

842,006. HORIZONTAL BOILER. Jeremiah Chadwick Parker, of Red Bank, N. J.

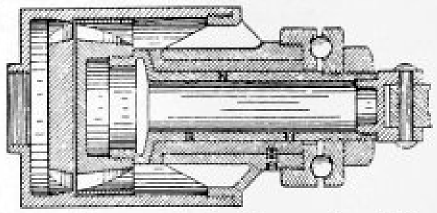
Claim.—In combination with a horizontal boiler, side walls



supporting the same, coils of pipe supported by said side walls and having their ends connected to said boiler, said coils lying entirely out of the normal passage of the combustion gases, and water lugs carried by said coils and entering recesses in said side walls. Four claims.

842,311. BOILER-TUBE CLEANER. Christian Gottwald, Cleveland, Ohio.

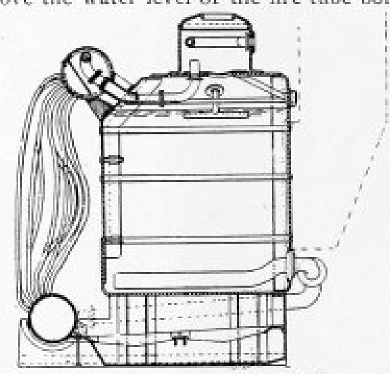
Claim.—In a boiler-tube cleaner, the combination with a non-rotating part having a transverse diaphragm provided with inclined passengers, said non-rotating part having a chamber which extends forward from said diaphragm, a removable journal-bearing mounted on the outer end of said chamber, a removable bushing secured within said journal-



bearing, its rear face provided with an enlarged flange, a hollow shaft rotatably mounted within said bushing and enlarged at its rear end to conform to the enlarged flange on said bushing, a threaded rear extension on said hollow shaft to receive the rotary part of the motor, and a threaded forward extension to receive a centrifugally-acting cutting-tool. Three claims.

843,497. STEAM GENERATOR. Johann Schütte, Bremerhaven, Germany.

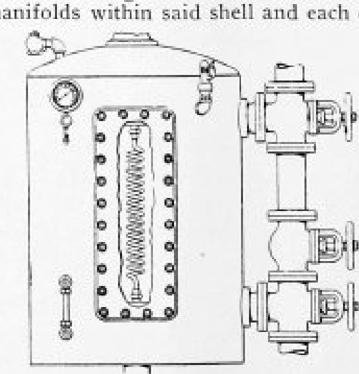
Claim.—In a steam boiler the combination of a fire-tube boiler having the top part of its rear wall inclined, a steam chamber above the water-level of the fire-tube boiler, a roomy



short tube forming an open connection between the fire-tube boiler and said steam chamber, the lower open end of said roomy tube being connected to the inclined top part of the rear wall of the fire-tube boiler, a water chamber, water-tubes connecting said water chamber with the steam chamber, and a fire grate below the fire-tube boiler. Nineteen claims.

843,791. FEED-WATER HEATER. Mark K. Bowman, Montclair, N. J., assignor to the James Reilly Repair & Supply Company, Jersey City, a corporation of New Jersey.

Claim.—A feed-water heater comprising a shell having pipe connections for admitting steam thereto and an outlet, lower and upper manifolds within said shell and each composed of a



series of concentric hollow communicating rings, and several series of pipe coils connecting the rings of the lower manifold with those of the upper manifold, combined with a supply pipe for feed-water leading to one of said manifolds, and a delivery pipe for the heated feed-water leading from the other manifold. Three claims.

THE BOILER MAKER

VOL. VII AUGUST. 1907 No. 8

THE LAYOUT AND CONSTRUCTION OF STEEL STACKS.

Stacks, or chimneys, serve two objects, the first and most important being that they create a draft or current of air (equal in intensity to the difference between the weight of the column of hot gases inside the chimney and a column of air outside of the same height and sectional area) through the furnace, so that a sufficient quantity of air is brought into contact with the fuel in a certain space of time to produce the desired rate of combustion.

The factors which determine the capacity of a stack to produce a certain draft are the height of the stack, the difference in temperature between the air outside and the gases inside, and the friction opposing the flow of the gases through the furnace, boilers, up-takes and the stack itself, while the capacity of the stack to handle various quantities of hot gases depends upon the velocity and density of the gases and the sectional area of the stack. Since the density of the gases decreases with an increase in temperature, it is evident that to produce a strong draft the temperature of the gases should be as high as practicable without undue loss of heat. Since, however, 550 degrees F. is the temperature at which the maximum weight of gas will be delivered, the temperature will not have any very appreciable effect in determining the size of the stack.

The main points to be considered, therefore, are the height and area. The height must be great enough to produce sufficient draft to burn the kind of fuel to be used at a certain desired rate of combustion, and the sectional area must be large enough to carry off the gases produced at this rate of combustion.

In laying out a stack for boilers of a certain horsepower, if either the height or the area is assumed, the other quantity may be determined from the following formula:

$$H.\ P. = 3.33\ (A - 0.6\ \sqrt{H})\ \sqrt{H},$$

where $H.\ P.$ = horsepower of the boilers, A = area of stack in square feet, H = height of stack in feet. This equation, which was deduced by Mr. William Kent some time ago, has been widely used, and when the assumptions upon which it is based and its limitations are fully understood it can be depended upon to give very good practical results. The assumptions upon which the formula are based are: That the draft varies as the square root of the height of the stack, and that the effective area shall be computed from a diameter 4 inches less than the actual diameter of the stack. The constants for this equation were determined from the performance of a typical chimney, and are, therefore, entirely empirical.

Assuming a coal consumption of 5 pounds per horsepower per hour, Table No. 1 was compiled by Mr. Kent, the values being computed by means of the above equation. In any case, if the horsepower is given and the height assumed, as is frequently the case in the design of a stack, the effective area E,

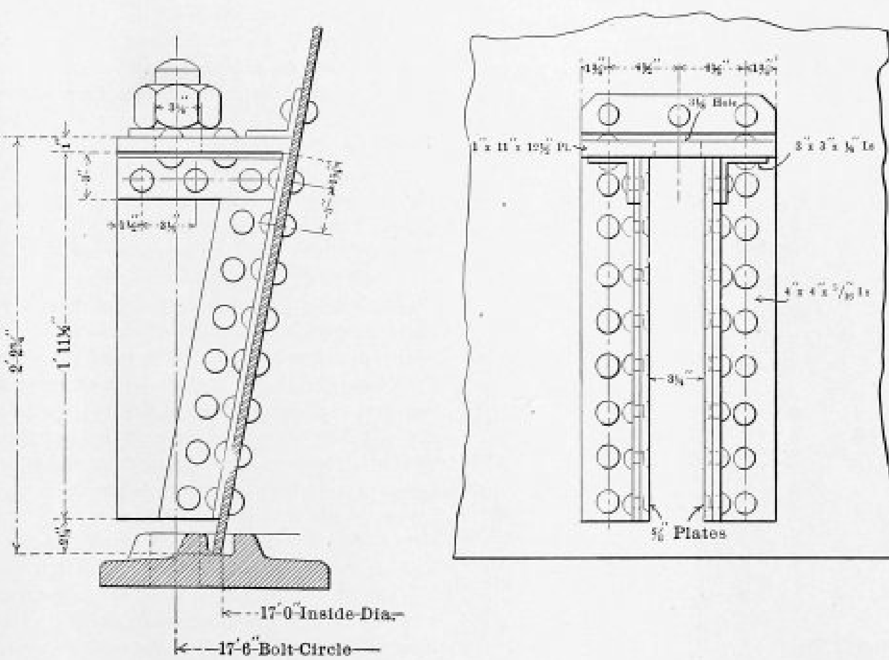


FIG. I.—METHOD OF ANCHORING SELF-SUPPORTING STEEL STACKS.

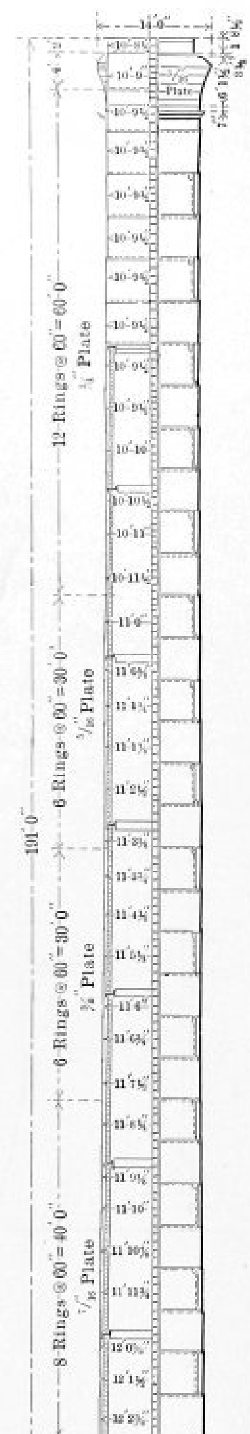


FIG. 2.—SELF-SUPPORTING STEEL STACK, 191 FEET HIGH BY 10 FEET DIAMETER.

which is a section whose diameter is 4 inches less than the diameter of the stack, may be determined from the following formula:

$$E = \frac{.3\ H.\ P.}{\sqrt{H}}$$

The area of the stack is frequently made equal to about one-eighth the grate area and then the height is determined to give the required draft.

Steel stacks are of two kinds, guyed and self-supporting. Guyed stacks depend for their stability upon ropes or wires which are attached to the stack by means of an angle-bar or Z-bar ring, at about two-thirds the height of the stack from the ground. There should be at least four guys for a stack, the rods being usually of ½ or ¾-inch iron, depending upon the size of the stack, since the load which they are to support is that due to the pressure of the wind upon the surface of the stack. This is usually figured as 25 or 30 pounds per square inch of projected area. If the stack is very tall, two sets of guys should be used, fastened at different points on the stack. Since a guyed stack must be only strong enough to sustain its own weight, it is a light and cheap form of stack to construct, and is usually made in the form of a straight tube of in-and-out rings. In that case all the sections can be rolled to a cylindrical shape and riveted up in the shop, and afterwards easily erected in position without the aid of expensive scaffolding. As guyed stacks are seldom much over 100 feet high, the thickness of plate used is usually, No. 10, 12 or 14-gage. Due to their lightness, this form of stack does not require a substantial foundation, and they are frequently set directly upon the breeching of the boiler.

Self-supporting stacks, an illustration of which is given in Fig. 2, require a more careful design, as they must sustain not only the load due to their weight but also that due to the pressure of the wind. They are usually given a taper of about 1/16 inch to the foot, and the bottom is flared out or made bell-shape, to give added stability, the diameter of the base being about one-tenth the height of the stack. The stack rests upon a base plate usually of cast iron of the shape shown in Fig. 3. This base is usually cast in four or more sections, which are fastened together with bolts through the flanges or lugs, which are cast on the ends of each section, as shown in Fig. 4. The base plate for small self-supporting stacks is sometimes cast in one piece with cored rivet holes in the flange. The lower course of the plating of the stack is then riveted directly to the base plate, which in turn is anchored to the foundation by holding-down bolts. This construction is, however, not reliable, and should not be used for large stacks, since the wind pressure brings a tension stress on one side of the stack at the base where it is fastened to the cast-iron ring, and the cast iron, which has a low tensile strength at best, cannot be relied upon to sustain the load, as there are frequently blow holes or other imperfections in the casting.

The construction which is now used to replace this is shown in Fig. 1. The lower course of the stack simply rests in the groove of the base plate without being riveted to it. The holding-down or anchor bolts are fastened directly to the shell through steel brackets, as shown. Two bracket plates, of the form shown in the detail, Fig. 1, are fastened by angles to the shell a few inches apart. Riveted to the top of these brackets is a heavy plate in which a hole just large enough to receive the anchor bolt has been drilled. The tension stress is then transmitted from the shell to the bolt through steel, whose strength can be accurately figured, and which can be depended upon to sustain the load for which it is designed.

The foundation for the stack depends upon the character of the soil upon which it is to rest, and should be designed by some one who has had considerable experience in such work.

The opening from the flues leading from the boilers to the stack should be located, if possible, underneath the stack, as any opening cut in the shell greatly reduces the strength of the stack.

Nearly all self-supporting stacks and some guyed stacks are protected by firebrick lining. This lining is made sufficiently heavy to sustain its own weight, and is not connected to the shell except at intervals of 40 or 50 feet. A lining is seldom continued clear to the top of the stack, as the gases are sufficiently cool by the time they have traveled about three-quarters the length of the stack, so that no injury will result from their contact with the steel. The sections of lining are supported as shown in Fig. 5. A Z-bar ring is riveted inside the stack, and to the inner flange of the bar a wide plate is bolted, which extends several inches below the bar. The lower section of the lining extends to within about 1½ inches of the Z-bar, in order to allow for expansion and is supported by the plate. The next section of lining rests upon the Z-bar, and is supported through it by the shell. An inch or so of space is left between the lining and the shell to allow for expansion.

The top of a stack is usually flared out for the sake of appearance to form a cornice or cap. This cap is made of light plates and, of course, has nothing to do with the strength or

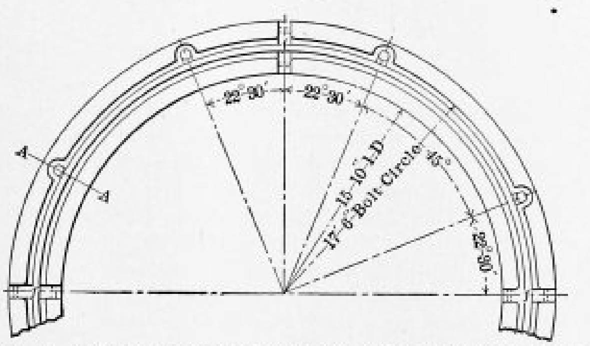


FIG. 3.—SECTION OF BASE PLATE USED WITH SELF-SUPPORTING STACK.

stability of the stack. In order to stiffen the top of the stack an angle or Z-bar ring is usually placed around it, while just below the cap another Z-bar ring is riveted to the shell to provide a place for attaching scaffolding for painting the stack. For this purpose also a light iron ladder is usually riveted to one side of the stack. Sometimes in the case of a very large stack a light spiral staircase runs part way up the outside of the stack.

The stability of the stack may be determined as follows: Find the total weight of the stack and lining. This may be considered as a vertical force acting downward through the middle of the foundation. Find the total pressure on the chimney, which would be approximately 25 × the height × the diameter. This may be considered to act in a horizontal direction at the middle point of the chimney, so that its moment about the base would be the total force × ½ the height of the chimney. Divide this amount, due to the wind pressure, by the weight of the chimney, and the result will be the distance from the middle of the foundation to the resultant force due to the combined forces of wind pressure and weight. For stability this force should act within the middle third of the width of the base.

The stress per lineal inch at any section may be determined from the following formula:

The stress per lineal inch at any section = moment due to wind pressure in inch pounds ÷ ¼ × 3.1416 × (diameter in inches)^2. Assuming a safe fiber stress of 10,000 pounds per square inch, the thickness of plate necessary to sustain this stress may be figured from the following formula:

Thickness in inches

$$= \frac{10{,}000 \times \text{the efficiency of the horizontal joint.}}{\text{stress per lineal inch}}$$

The calculation for the stress per lineal inch should be made at a number of sections in order to be sure that the stress at any point does not exceed the safe working stress of the material. If desired, more elaborate computations may be made for the strength of the riveted joints subjected to the bending

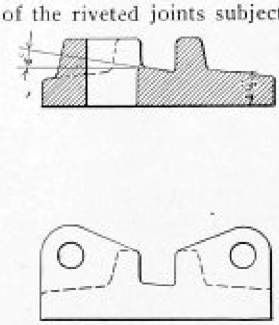


FIG. 4.—SECTIONAL VIEW AND FLANGE OF BASE PLATE.

strain due to the wind pressure. In the case of the horizontal joint the rivets on both the windward and leeward side of the stack will be in shear, although the joint on the windward side will be in tension and on the leeward side in compression.

In order to follow through the calculations which must be made in the layout of a particular stack, assume that it is required to build a stack for boilers which have a total horsepower of 285 and a total grate area of about 60 square feet. The effective area of the stack should be about one-eighth the total grate area, or about 7½ square feet. The diameter corresponding to this area would be about 9 feet 8 inches. The actual diameter of the stack, however, according to the as-

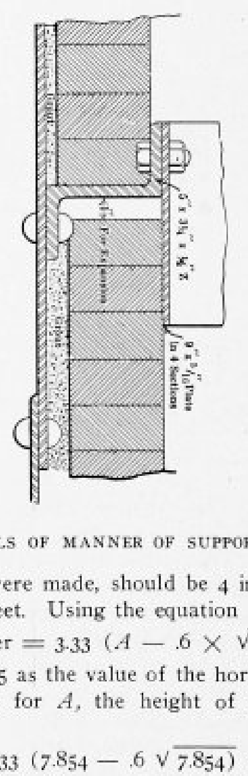


FIG. 5.—DETAILS OF MANNER OF SUPPORTING LINING.

sumptions which were made, should be 4 inches greater than this, or about 10 feet. Using the equation

$$\text{Horsepower} = 3.33\ (A - .6 \times \sqrt{A})\ \sqrt{H},$$

and substituting 285 as the value of the horsepower and 10 × .7854 as the value for A, the height of the stack may be determined:

$$285 = 3.33\ (7.854 - .6\ \sqrt{7.854})\ \sqrt{H}$$
$$\sqrt{H} = 13.8$$
$$H = 191$$

Therefore, the required dimensions of the stack are: Height, 191 feet; diameter, 10 feet. The details of a stack built to these dimensions are shown in Fig. 2. The actual diameter of the shell of the stack will be greater than 10 feet, since the inside diameter of the lining should be at least 10 feet. As the lining at the top should be approximately 4 inches thick, the actual diameter of the stack at the point where the lining is stopped should be about 10 feet 9½ inches.

A computation should be made for the thickness of plate at intervals of 25 or 30 feet throughout the height of the stack. Using the formula quoted in the first part of the article for the thickness of plate, we have at a height of 25 feet:

$$T = \frac{11 \times 166 \times 30 \times \frac{166}{2} \times 12}{.7854 \times (12.25 \times 12)^2 \times 10{,}000 \times .75}$$

$T = .43$, or, approximately, 7/16 inch. This is assuming a mean diameter of 11 feet with a diameter of 12 feet 3 inches

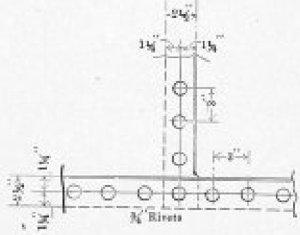


FIG. 6.—DETAIL OF RIVETING OF TOP RINGS.

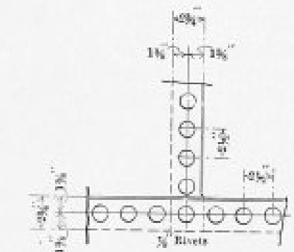


FIG. 7.—DETAIL OF RIVETING ABOVE 65 FEET.

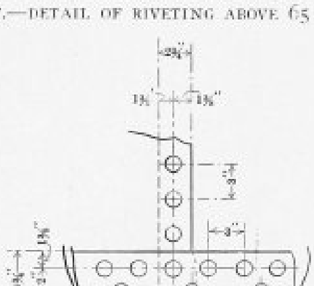


FIG. 8.—DETAIL OF RIVETING ABOVE 25 FEET.

at the height of 25 feet, and that the horizontal seam is double riveted with an efficiency of 75 percent.

Making the same computation at a height of 65 feet, where the diameter is 11 feet 7 inches, and the horizontal seam single riveted with an efficiency of about 60 percent, T is found to be about .344, or ⅜ inch. At a height of 95 feet, where the diameter is 11 feet 3 inches, T is found to be about .21 inch. As it would not be advisable, however, to use anything less than ¼-inch plate, the next 30 feet of the stack should be constructed of 5/16-inch plate, leaving only the last 60 feet of ¼-inch plate.

The details of the riveting for the different thicknesses of plate are shown in Figs. 6, 7, 8 and 9. It will be seen that the double-riveted horizontal seams give an efficiency of about 70 percent, while the single-riveted seams give an efficiency of at least 60 percent.

The stack is constructed of rings each 60 inches wide, made up of three plates. Where the diameter exceeds 12 feet each ring should be made in four sections. Each ring is in the form of the frustum of a right circular cone, and may be laid out according to any of the methods described on page 108 of the April issue of THE BOILER MAKER. In the stack shown in Fig. 2 each ring is an inside ring at its lower edge and an outside ring at its upper edge. This style of construction is frequently reversed. In determining the length of the plates which form a ring an allowance of about seven times the thickness of the plate should be made between an outside and an inside ring.

The plates are sheared, punched, scarfed and rolled in the shop, but the plates which form a ring are not riveted together

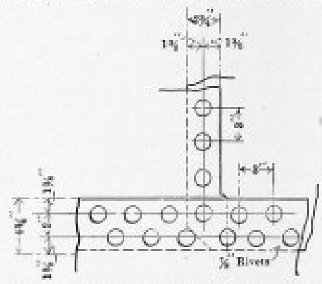


FIG. 9.—DETAIL OF RIVETING AT BASE.

until they are erected in place. The scaffolding is built up on the inside of the stack, the plates being hoisted by means of a short jib crane on top of the scaffold. The seams should all be calked after riveting, so that there will be no leakage of air into the stack. This is one of the important advantages which a steel stack has over a brick chimney, since the brick work in a chimney frequently becomes loose and allows the air to leak into the chimney, impairing the draft.

A cap or cornice for a stack may be constructed in one of two ways; either as shown in Fig. 10 of narrow plates in the form of circular rings, or, as shown in Fig. 11, of narrow strips

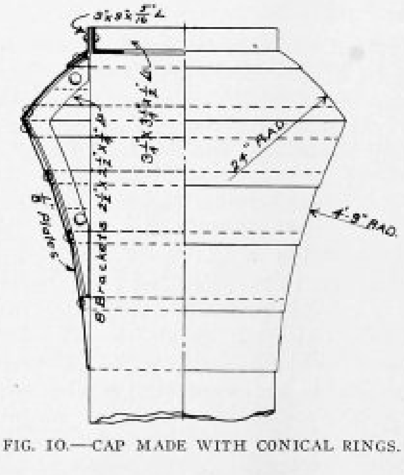


FIG. 10.—CAP MADE WITH CONICAL RINGS.

of plate which run lengthwise of the stack. In the first case, the layout of each ring is obtained in the ordinary way for finding the development of the frustum of a right circular cone. The dimensions for the diameter at the top and bottom of the ring and for the width of the ring being taken from a full-sized sectional drawing similar to that shown in Fig. 10. The plate used for these rings is seldom more than ⅛ or 3/16 inch thick, and, therefore, if made in narrow rings, the cap will have a smooth appearance. The proportions governing the general outline of the cap will depend upon the height and diameter of the stack.

The plates which form the cap are supported by brackets, as shown in the detail, Fig. 10. In this case eight brackets are provided, made of 2½ by 2½ by ¼-inch angle-bars, forged to conform to the outline of the cap. These brackets are riveted by clips to the shell of the stack. A 3 by 3 by 5/16-inch angle is riveted around the upper edge on the cap after it has been beveled to the proper angle. A similar angle is riveted at the corner of the cap. The plates are riveted together and are secured to the angle-iron brackets by 5/16-inch rivets spaced at about 4 inches pitch.

The layout of the strips for a cap constructed according to the second method is shown in detail in diagrams *A, B, C* and *D*, Fig. 11. The outline of the cap is first drawn full size, and

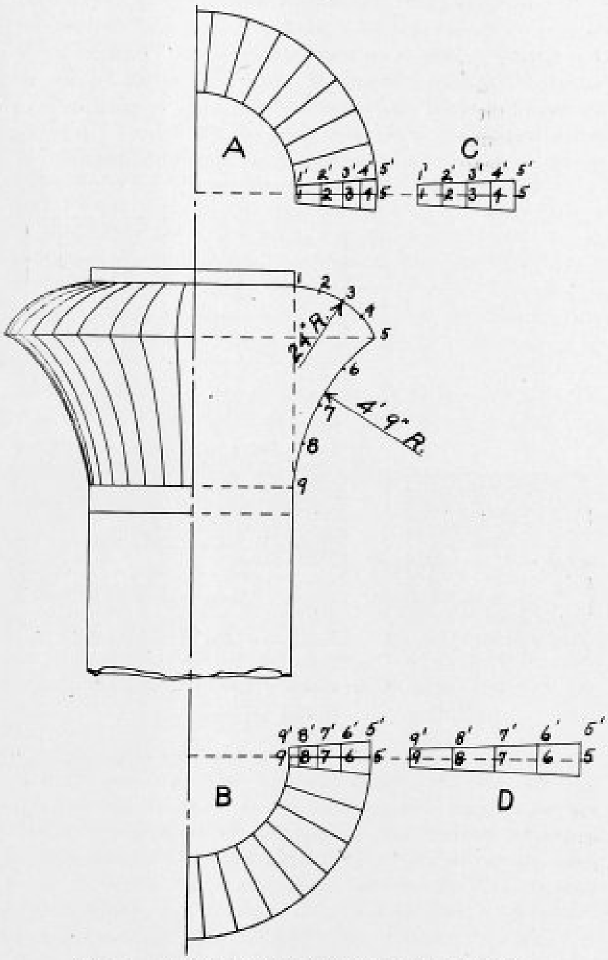


FIG. 11.—LAYOUT OF CAP WITH VERTICAL STRIPS.

the arc 1-5 is divided into any number of equal spaces, as at points 2, 3 and 4. These points are projected to the plan view at *A*. In order to give a smooth appearance to the cap, it should be constructed of from twenty to thirty strips. In this case thirty-two have been taken, thus dividing a quarter of the cap into eight equal strips. Having divided the quarter plan *A* into eight equal spaces, the pattern for one of these strips may be laid out as at *C*, where 1-5 is made equal to the length of the arc 1-5 in the outline of the cap, and the offsets 1-1′, 2-2′, 3-3′, etc., are measured from the corresponding lines in *A*.

In a like manner the pattern for the lower part of the cap may be obtained as at *D*, where the length of the strip 9-5 is made equal to the length of the arc 9-5 in the outline, and the offsets 9-9′, 8-8′, 7-7′, etc., are taken from the corresponding lines in the plan view *B*. The laps and allowances which must be made, due to bending the material, should be added to these patterns. The brackets and frame work for this cap are similar to those shown in Fig. 10.

Instead of making the lower rings of a very large and heavy stack in the form of conical surfaces, a section from 15 to 20 feet high is frequently made bell shape, as shown in Fig. 12. This gives the stack a more graceful appearance, and can be so constructed as to give a firm foundation for the rest of the stack. The bell portion, like the fancy top or cap shown in Fig. 11, is constructed of narrow strips of plate which run lengthwise of the stack. These, as may be seen from the

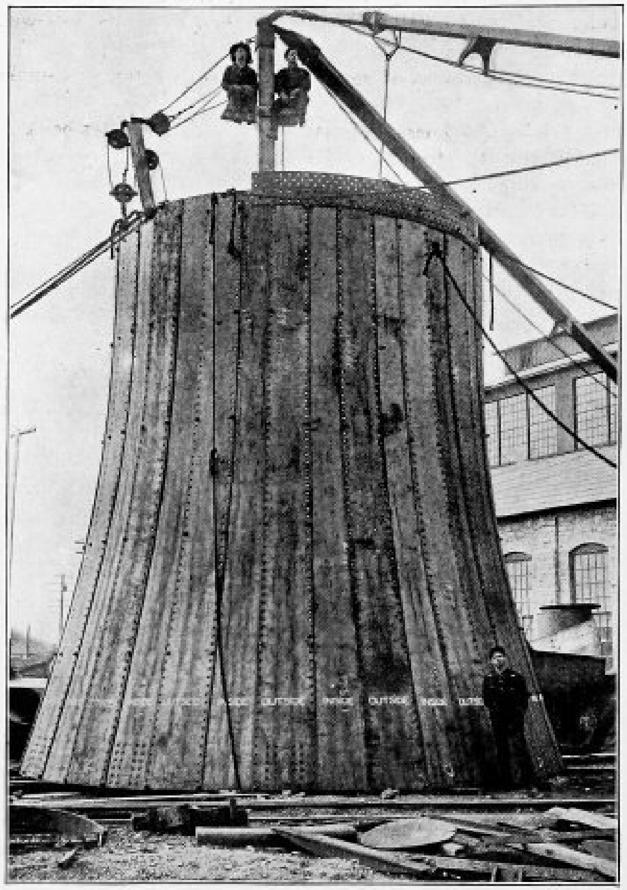


FIG. 12.—BELL SHAPED PORTION OF SELF-SUPPORTING STACK.

illustration, are joined with lap seams, the alternate strips being outside and inside. The layout of these strips may be obtained in the same way as the strips for the cap, which was described in connection with Fig. 11.

Consular reports show that while the imports of locomotives in Brazil have trebled in the last three years, the proportion of the imports from the United States have increased over six-fold, and that while the increase in the total imports between 1905 and 1906 was about 75 percent the increase from the United States alone was something like 250 percent.

The three classes of locomotives used in Brazil are ordinary railroad locomotives of varying weight and speed, hill climbing or cog locomotives for mountain work and small locomotives for use on short railways upon coffee and sugar plantations. American manufacturers are furnishing their full proportion of the small locomotives and ordinary railroad locomotives, but a single firm in Germany, which makes a specialty of cog locomotives, has secured the bulk of this trade.

One of the causes of a serious loss in the transmission of compressed air is pumping the air of the engine room rather than air drawn from a cooler place. It is claimed that this loss amounts to from 2 to 10 percent.

Rivet Heating Forges.

Some valuable information regarding the best forms of forges for heating steel rivets was brought out in the papers which were submitted in competition for the Champion prizes. Mr. William Horsley, of New Haven, Conn., wrote on this point as follows:

During the past seven years I have tried nearly all known methods for heating steel rivets, and I unhesitatingly declare as a result of this experience, that everything taken into consideration, *fuel oil forges* are the *best*, for the following reasons:

First. Cleanliness of operation; the entire absence of smoke, gas or smell.

Second. Quickness and ease in starting, 5 minutes being all that is required from a cold forge to a rivet hot enough for the machine.

Third. Absolute uniformity of the heat, all parts of the rivet being alike, no cold heads with the points burned off.

Fourth. Ease with which the heat can be controlled, whereby the rivets are heated any color required, cherry red, bright red or white, all the rivets getting the same amount of heat.

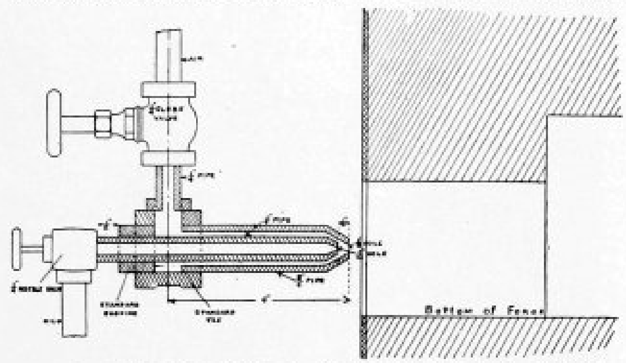


FIG. 1.—SECTIONAL VIEW OF AN EASILY MADE OIL BURNER.

Fifth. The entire absence of that most aggravating collection of burnt rivets usually found around a coal forge.

Sixth. Ease of operation; any man or boy can become expert in one-half a day, which is simply impossible with coal or coke.

Seventh. Economy. We have in our works four hydraulic riveters, and each machine has its own forge, but if two riveters are using the same size rivets, one small forge using 8 cents worth of oil per hour will easily heat more rivets than they can use, no matter whether they are ⅝-inch or 1-inch diameter.

Now, I have not come to the above conclusion before trying about everything in the market for doing this work. We had here in our works, when I took charge, forges for heating rivets with pea coal. These proved unsatisfactory for the following reasons:

Their capacity was limited and the output of a machine was restricted to the number of rivets a boy could heat in them. They did not heat the rivet uniformly. The heater, to get a rivet white hot had to push the end of it down into the fire. The result was from 5 to 10 percent of burnt rivets. Then just about the time everything was running smoothly the heater had to go out after coal, and very often forgot to come back for half an hour. Another drawback was the ashes and dirt, which would accumulate in spite of all you could do. I tried coke with no better results. It made too hard a fire, and to handle it required a great deal of skill not usually found in the average rivet boy, and produced more burnt rivets in a day than the coal did in three days. We cut that out and returned to coal.

Some three or four years ago a young man came into our works with a gas rivet heating furnace, and asked if we would let him put it in on trial. We let him do this, but at the end of a week we had to request him to remove it. It would heat rivets all right as long as myself or the expert stayed with it, but the heater never could get the right mixture of air and gas for proper combustion, and the result was scale the thickness of the bark of a tree in a few minutes. I had never seen, or have since seen anything like it. The scale would come off and look just like a shell formed into the shape of a rivet, and so thick that it could not be crushed in the hand. Another drawback was the fact that it took about $3.00 per day for gas at $1.00 per thousand feet. We discarded the gas and went back to pea coal.

Not being satisfied, however, I took a trip around among the largest shops in several adjoining States, and discovered that I was not "in the swim" on heating rivets. I came home and adopted a furnace, using soft coal with a retort on one end of it, where the coal was burnt and the flame in passing over the brick bottom, on which the rivets were laid, and returning underneath heated the rivets. By this means the rivets and coal

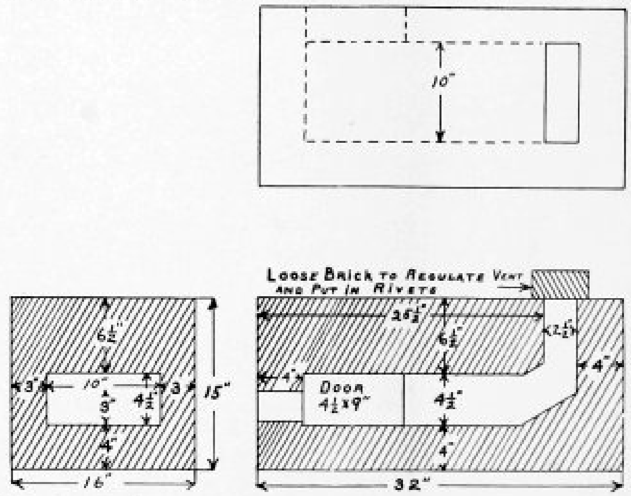


FIG. 2.—ARRANGEMENT OF FORGE USED WITH BURNER SHOWN IN FIG. 1.

did not meet. The rivets were heated uniformly and without burning, and the output was increased over the old pea coal system at least 100 percent, one large forge heating for two hydraulic riveters, but we still had the nuisance of smoke, coal dust and ashes, and as one forge was used by two heaters we had an average of four fights per week, because the other fellow would not do his share of the firing. Then along came the man with the oil forge. We had tried three different kinds and discarded every one of them. They blew the heat out in the face of the heater boy; could not be regulated so as to work economically, and used an excessive amount of compressed air to run them. After a fair and impartial trial we did not adopt any of them, but went back to the coal forge again.

After this you would naturally think that I would give up experimenting, but I did not. I took another trip around, and among the shops visited found one using oil in the flanging furnace. I asked the superintendent whose make of burner he was using, and he said he was using his own. It was composed of about 20 cents worth of pipe and fittings and two ¼-inch valves. He gave me a blue print of the device, and this is what I am using to-day, obtaining perfect satisfaction from it. It can be made in any shop in one hour, and can be run to melt the furnace or throttled down to a whisper, and the outside cost need not exceed $2.00 per burner.

This burner, however, was no good without a forge made to fit the conditions, which must be in the nature of a slow, continuous heat from the coldest rivet to the hottest, and I set about designing a forge, which I am now using, and which is shown in the accompanying drawing. The forge proper consists of a sheet iron box made of No. 10 or 3/16-inch steel plate lined with fire tile or brick, as shown in the sectional view. The burner is made of common iron pipe and connected on one side to an air pressure line, which may be from 20 to 100 pounds per square inch air pressure. In my case I use the regular air tool supply. The other end is connected to an oil tank or oil pump, which brings the oil to the burner. To operate this forge, light a piece of old waste, put it into the forge, turn on the air slowly at first, then turn on the oil. As soon as it ignites it will burn of itself, and in a few minutes when the bricks get hot it can be cut down until the flame is not much larger than an ordinary gas jet, if the quantity of rivets being used is small. Or it can be burned up to suit almost any quantity of rivets or degree of heat desired. The principle on which this forge works, and which gives it the success which it has, is this: The cold rivets are put into the coldest part of the fire, and the hot rivets are taken out of the hottest part, and the length of time between when the rivets are put in and taken out allows of a gradual soaking heat, which penetrates every portion of the rivet, and makes them uniform. The rivets, when hot, are taken out and the colder ones keep rolling down into the bottom of the fire to take their places. Cold rivets are then added from time to time, as necessary, by dropping them into the opening on top of the forge, where they gradually absorb the waste heat as it passes out of the forge.

Another point in favor of this forge is this: In blowing oil into a forge there must be a vent for the escape of waste

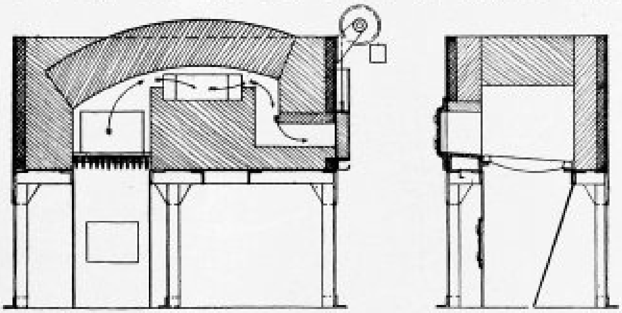


FIG. 3.—HEATING FURNACE IN WHICH THE FLAMES DO NOT STRIKE THE RIVETS.

gases, and in all commercial forges of this type which I have seen the only vent is the place where rivets are put in and taken out. This makes it very uncomfortable for the heater, as he cannot approach the fire without having the flame blow in his face, a thing which is entirely overcome by the forge I have described, and also in all the forges on the market you must throw the cold rivet into the same place where the hot ones are, which has a chilling effect on the fire, and also on those rivets already hot, which I believe should be avoided.

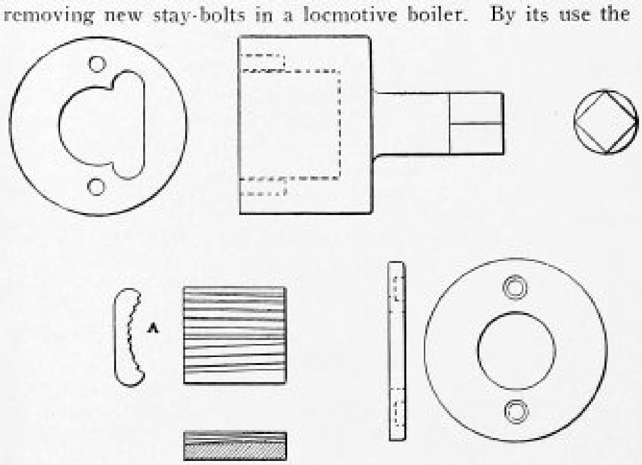
This forge, although very small, will hold enough of ordinary size rivets to keep a hydraulic riveter going for ½ hour, and as fast as ten or twelve rivets are driven the heater drops in ten or twelve more to take their place, and all he has to do is to pick out the rivets and drop them at the machine, there being practically no limit, except the capacity of the machine, to drive them. The effect of soaking rivets in the fire too long during noon or other time is left out entirely on this type of forge, because if the machine is stopped for only ten minutes, the boy shuts off the valves and the forge stops until more rivets are required; thus there is absolutely no fuel being consumed except when actually working. With the proper mixture of air and oil, which is so simple that a child can operate it, we obtain perfect combustion, and thus avoid all deteriorating effects, which are sometimes caused from the compressed air blowing on the rivets.

There being no patent of any kind on either the forge or the burner, and both being simplicity itself, it is not necessary to spend from $85 to $150 to try them out, as any foreman boiler maker can go ahead and make his own forge for a few dollars, get a barrel of crude oil or the cheapest kind of fuel oil, and get the same satisfactory results that have been obtained in this shop.

Mr. William Voris, an inspector for the Babcock & Wilcox Company at Barberton, Ohio, described the most suitable furnace for heating steel rivets as being one in which the flames and gases do not come directly in contact with the hearth, and he submitted the sketch shown in Fig. 3 to illustrate this point. In this furnace the rivets are heated by radiation; that is, by the heat given off by the incandescent fire brick. No more than eighteen or twenty rivets should be placed in the furnace at one time. After these have become well heated, another lot should be inserted directly back of the first ones; then by the time the first lot is all drawn the second lot is ready to be brought to the front of the furnace and another lot thrown in. It should take from four to six minutes to heat one lot to the required temperature.

A Staybolt Chuck.

The drawing illustrates a stay-bolt chuck, designed and built in the tool room of the Atchison, Topeka & Santa Fe Railway at San Bernardino, Cal. This chuck is used for putting in and removing new stay-bolts in a locmotive boiler. By its use the



A STAYBOLT CHUCK FOR USE WITH AN AIR MOTOR.

time and expense of squaring the heads of stay-bolts is eliminated.

The chuck being inserted in an air motor is placed over the end of the stay-bolt, the piece *A* clutching it automatically. Machine steel is used throughout in the manufacture of this tool, with the exception of the clutch, which is of tool steel and hardened.—*American Machinist.*

Recently, a Southern boiler inspector visited a new risk consisting of a single boiler, and the negro engineer received him and did the honors of the occasion. The feed pipe entered the boiler through the lower connection between the boiler and the water column, with the result that the water in the glass was vibrating, now full, now empty, from one end to the other.

Of course, this was against all mechanical rules, as such a connection attached to a water column destroyed its usefulness. He said to the ebony attendant, "How do you know, or how can you guess, the water level in the boiler with this arrangement?"

"Mistah Boss-man," he said earnestly, "ah doan know, and ah doan guess erbout dat watah. Ah des reckons, sah. In de mawnin', sah, ah sees de watah am half way in de glass, and when de enjine gits to toten de load, ah sets de dijector on an' dat air watah begins to fluttah, sah, des lak a bird, an' from den till ah shet down ah des reckons, sah, ah des reckons, whar dat watah am."

THE PIPING AND FITTINGS FOR A TUBULAR BOILER.

BY F. C. DOUGLAS WILKES.

PART I.

THE MAIN STEAM OUTLET.

In order to figure comprehensibly on the piping and fittings for any boiler it is obvious that we must have some data as a basis for such calculations. Let us use for the basis of the following calculations an ordinary multi-tubular boiler, such as has been described by Mr. H. S. Jeffrey in preceding issues of The Boiler Maker, namely, a 60-inch by 14-foot boiler having 74 3-inch tubes. Having this, and knowing that the ratio of heating surface to grate area in boilers of this type, ranges from 30 : 1 to 40 : 1, we can readily figure the grate area. The heating surface must be figured first, and and it may be approximately found from the formula:

$$T \cdot H \cdot S = C \times L \times \frac{2}{3} + A + \frac{2}{3} \times a - 2 \times \text{sectional area of tubes.}$$

Where:

$T\ H\ S$ = total heating surface

C = Circumference of boiler in feet.

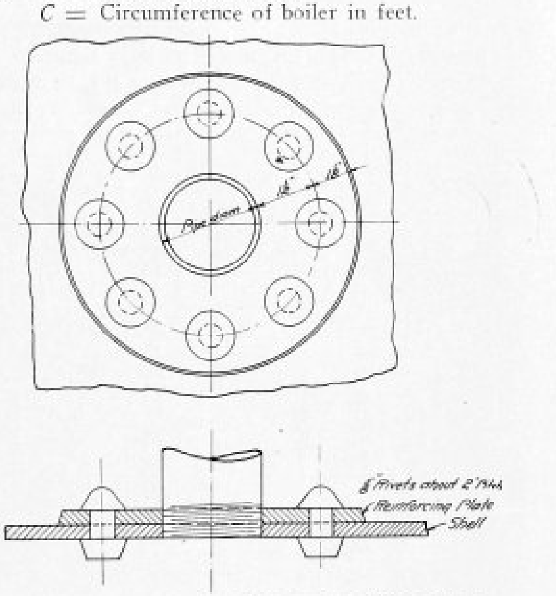


FIG. 1.— SIMPLEST FORM OF REINFORCING PLATE.

L = Length of boiler in feet.

A = Area of surface of tubes in contact with water.

a = Area of tube sheets.

In the problem under consideration this will amount to 916 square feet. Now, taking the mean of the ratios of the heating surface to grate area, namely, 35 to 1, we have for our grate area:

$$\frac{916}{35} = 26.2, \text{ or say, 27 square feet.}$$

Having the above data as a basis we will now proceed to find the size of the steam opening.

The size of the steam opening depends, of course, on the amount of water that the boiler will evaporate under normal working conditions. Sometimes this opening is figured according to the size, speed, etc., of the engine for which the steam is generated. As we have not taken any engine into account we will merely observe the method used without applying it to our case. To prevent undue reduction in pressure (there is bound to be some) between the boiler and the engine, due to the frictional resistance opposing the flow of steam, condensation, etc., the velocity of steam through a pipe of moderate length and with several bends should not exceed 85 feet per second, or 5,100 feet per minute. Then the area of the steam pipe may be found from the formula:

$$A = \frac{a \times s}{5{,}100}$$

Where: A = Sectional area of steam pipe in square inches.

a = Area of piston in square inches.

s = Piston speed, feet per minute.

Another formula which will be applicable in our case is

$$A = \frac{N \times V \times 144}{V_s \times 62.42}$$

Where: A = Sectional area of main steam pipe in square inches.

N = Number of pounds of water evaporated per minute.

V = Relative volume of steam.

V_s = Velocity of steam, feet per minute.

Note:—The relative volume of steam at any pressure is the volume of 1 pound of steam at that pressure as compared with the volume of 1 pound of distilled water at the temperature of maximum density.

We have seen what V_s should be, namely, 5,100 feet per minute, and the value of V may be found from any table of

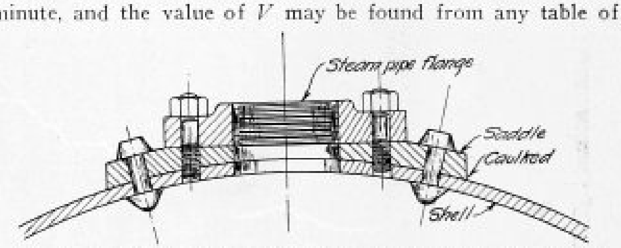


FIG. 2.—SADDLE BENT TO FIT SHELL AND PLANED TO RECEIVE PIPE FLANGE.

the properties of saturated steam, so it only remains for us to determine N.

In multi-tubular boilers the amount of coal burned per square foot of grate surface varies from 12 to 24 pounds per hour, mean 18 pounds. The amount of water evaporated per pound of coal varies from 8 to 12 pounds, the mean being 10 pounds. We have found the grate surface to be 27 square feet, therefore we can figure on $10 \times 18 \times 27 = 4{,}860$ pounds of water per hour, or 81 pounds per minute. Hence, substituting these figures in our formula we have

$$A = \frac{81 \times 169.3 \times 144}{5{,}100 \times 62.42} = 6.21 \text{ square inches,}$$

169.3 being the relative volume of steam at 150 pounds pressure.

$$\text{Diam.} = \sqrt{\frac{6.21}{.7854}} = 2.81, \text{ or } 2\ 13/16 \text{ inches.}$$

Having found the diameter of the steam pipe necessary for our boiler we will now consider the ways and means of fastening it to the shell. If this pipe had been found to have been smaller than 1½ inches in diameter it would be considered good practice to screw it directly into the boiler shell, and if it had been between 1½ and 2½ inches in diameter we could also fasten it direct to the shell, but the hole would be better if reinforced with a piece of plate riveted on so that the thread would have enough metal to secure a good hold. Fig. 1 shows such a reinforced hole.

As the diameter of our pipe is 2 13/16 inches we must attach it to the boiler by means of flanges, and there must therefore be some sort of seating block or saddle to overcome the cylindrical shape, and provide a flat surface for the flange of the pipe. There are several ways of providing this flat surface. First, we could take a thick piece of boiler plate, and after bending it to fit the boiler have it planed off on the convex side until it presented a flat surface equal in diameter to the diameter of the flange on our pipe. This piece is then riveted to the boiler and studs furnished for the pipe flange (see Fig. 2). This saddle is sometimes made of cast iron or cast steel, adapted either to the use of bolts with tee heads, as in Fig. 3, or with studs as in Fig. 4. These castings must be provided with a calking liner of thin steel or sheet iron placed between the casting and the boiler shell, so that the joint may be made tight by calking, as the castings themselves cannot be calked.

Instead of a saddle we may use what is commonly known as a nozzle for attaching the steam pipe to the shell. One advantage gained is that the diameter of the rivet circle is smaller, necessitating fewer rivets, and then bolts may be used

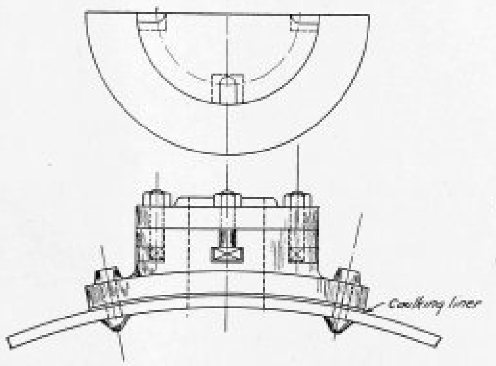


FIG. 3.—CAST STEEL SADDLE FITTED WITH TEE BOLTS.

instead of studs, which is very advantageous. Such a nozzle is shown in Fig. 5. These may be made of cast iron, cast steel or brass. The latter metal is generally specified for marine boilers where a very high class of work is demanded.

The thickness of the metal in a cast iron steam nozzle to suit our case is given by the formula:

$$T = \frac{D \times P}{4{,}000} + .5$$

Where: T = Thickness of metal in inches.
P = Pressure in pounds per square inch.
D = Internal diameter of nozzle in inches.

Substituting our figures we have

$$T = \frac{2.81 \times 150}{4{,}000} + .5 = .6054, \text{ say, } 5/8 \text{ inch.}$$

The finished thickness of the upper flange may be 1.3 times this thickness:

$$1.3 \times .6054 = .787, \text{ say, } 13/16 \text{ inch.}$$

On account of the lower flange being riveted to the shell and thus being subjected to the vibratory strain of driving the rivets, and the great strain due to the contraction of the rivet, it is well to add from 40 to 50 percent to the flange thickness thus found up to 1½ inches. Then our bottom flange becomes

$$.787 + .394 = 1.181, \text{ say, } 1\tfrac{1}{8} \text{ inches.}$$

THE SAFETY VALVE.

The next fixture of the boiler to consider is the safety valve. The types of safety valves in use may be classed under the following heads: Lever, dead weight and spring loaded valves. Lever safety valves are frequently used on stationary boilers, but they have the objection that the friction of the joints cause an extra resistance, and consequently an increase of steam pressure when the valve is rising. To reduce this friction to a minimum the bearing of the fulcrum on the fulcrum link and other bearings should be of the knife edge type. Dead weight valves are also used on stationary boilers. This type of valve is efficient and sensitive, and it is difficult to tamper with it by the addition of further weights than the valve is designed to carry. Spring-loaded valves are suitably adapted to all types of boilers. They are of two kinds: one in which the spring is not exposed to the action of the steam when working, and the other in which the spring is exposed

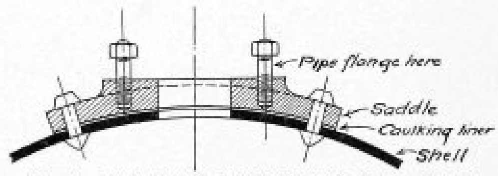


FIG. 4.—CAST STEEL SADDLE FITTED WITH STUDS.

to the action of the steam when working. It is advisable to furnish all safety valves with a lifting device by which the valve may be raised from its seat from time to time, so as to prevent the moving parts from becoming corroded and sticking, thus preventing the free action of the valve in performing its duty, which is to relieve the pressure in the boiler when it exceeds that at which the boiler is designed to work.

The safety valve should have a large area, in order to provide a large opening, for the escape of steam, with a small lift of the valve, otherwise the pressure of the steam may considerably exceed the pressure under which the valve began to rise before the valve lifts sufficiently to permit the free escape of the steam. The valve should not allow the pressure of the steam to rise above a fixed limit, and when this limit is reached it should discharge the steam so rapidly that very little or no

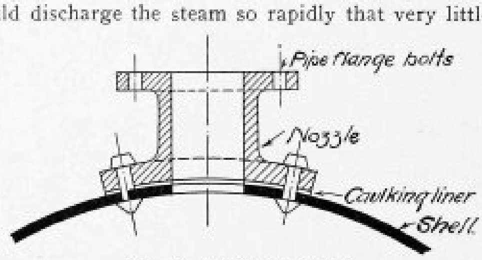


FIG. 5.—STEAM NOZZLE.

increase in the pressure of the steam can take place, no matter how rapidly the steam may be generated.

The area for the safety valve of a boiler may be determined from the grate area by the formula:

$$a = \frac{A \times 4}{\sqrt{P}}$$

Where: a = Area of valve in square inches.
P = Working pressure in pounds per square inch.
A = Area grate surface in square feet.

Substituting our figures we have

$$a = \frac{27 \times 4}{\sqrt{150}} = \frac{108}{12.24} = 8.825 \text{ square inches.}$$

$$\text{Diam.} = \sqrt{\frac{8.825}{.7854}} = 3.35, \text{ say, } 3\tfrac{1}{2} \text{ inches.}$$

From the evaporative power of the boiler the area of safety valve may be found approximately by the formula

$$a = \frac{E}{40 \times \sqrt{P}}$$

Where: E = Evaporating capacity of boiler in pounds per hour.
P = Working pressure.

Substituting we have

$$a = \frac{4{,}860}{40 \times \sqrt{150}} = 9.920 \text{ square inches.}$$

Whence diameter = 3.55, say, 3½ inches.

Another formula for the area of safety valves used by the British Board of Trade is

$$a = \frac{37.5 \times A}{G\,p}$$

Where: a = Area safety valve in square inches.
A = Grate area in square feet.
$G\,p$ = Absolute pressure = boiler pressure + 14.7

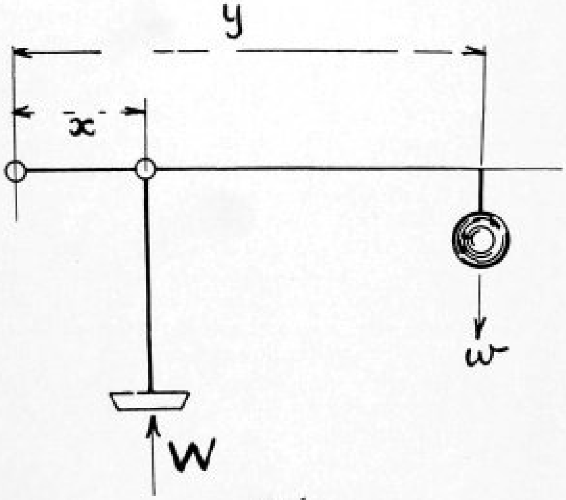


FIG. 6.

In our case

$$a = \frac{37.5 \times 27}{164.7} = 6.14 \text{ square inches.}$$

Whence diam. = 2.80 inches, say, 3 inches.

The weight of steam that will escape in an hour through a square-edged opening, like that occurring in a safety valve, may be approximately determined from the formula:

$$W = \frac{A\,P}{.023}$$

Where: W = Weight of steam in pounds discharged per hour per square inch of opening.
$A\,P$ = Absolute pressure of steam in pounds per square inch.

The weight on the lever of a lever and weight valve is easily found by finding the total pressure on the valve, due to the pressure at which the valve is to open. This found, the principal of the lever and fulcrum is applied (Fig. 6).

Let W = Load on valve due to steam pressure.
w = Weight of ball.
x = Distance of ball from fulcrum in inches.
y = Distance of point of contact of valve spindle with lever from fulcrum.

then $x \times w = W \times y$

or $$w = \frac{W \times y}{x}$$

Having found W and decided on the distances x and y, the weight of ball may be found by substituting these values in the formula. In dead-weight valves the weight of the valve and dead-weights is, of course, equal to the total pressure on the valve, which is equal to the area of the valve multiplied by the pressure at which the valve is to open.

In spring-loaded valves the size of the steel of which the spring is to be made may be found from the formula

$$d = \sqrt[3]{\frac{S \times D}{C}}$$

Where: S = Load on springs in pounds.
D = Diameter of spring in inches from center to center of wire.
d = The diameter, or side of square, of wire in inches.
C = 8,000 for round steel, 11,000 for square steel.

The pressure or load on a spring-loaded safety valve may be found by the formula

$$\frac{d^2 \times 2}{D} = S$$

Where: d = Diameter of wire in sixteenths of an inch.
D = Diameter of spring in inches from center to center of wire.
S = Load on spring in pounds.

(To be Continued.)

Steel Versus Iron Flues for Locomotive Boilers.*

BY B. S. MORRISON.

METHOD OF WELDING STEEL FLUE ENDS TO STEEL FLUES.

In taking up the above topic it may be of interest to know that about twenty months ago a certain company sent a representative to Cedar Rapids to demonstrate how to weld a steel flue end on steel flues. The furnace was made ready for action with every possible care, and the demonstrator started in to weld *steel* to *steel*. After trying about twenty applications he decided that he did not have the right material for flue ends, so he sent to the company's offices to have more flue ends sent forward by the first express.

Upon the arrival of his special order a thorough test was again made with the same results as before. Among the many flues welded there was not a flue that could be passed as first class. Several were welded and then placed under the hammer, where one or two blows served to separate them again. This showed that the flues were not welded at all, but, instead, a very neat job of shrinking had been done. Every indication pointed to the fact that the flue end was merely shrunk onto the flue, although when complete the flue had from the outside every appearance of being welded.

Considerable stress should here be laid upon the composition of the metal after being submitted to a very severe white heat. (The heat necessary to weld a flue.) After being welded we found several flues which showed signs of being over-heated, and they were very much like a piece of cast iron. Of all the ends that were furnished to demonstrate the quality of welding steel to steel we had but a small margin, if any, that could pass inspection.

After the departure of the demonstrator we decided to try welding iron flue ends on steel flues. We obtained some very flattering specimens by this procedure, sufficiently so to warrant using them in one of our engines, which to my knowledge never gave any trouble other than that occasioned by ordinary service. Afterwards a full set of steel tubes were applied, in what is known as our 20-B class engine. Engine 1,001, which received a full set of steel tubes on October, 1905, went to the shop December, 1906, for a fire-box which developed fourteen

* A paper presented at the Boiler Makers' Convention, May, 1907.

months continuous service, during which time a great number of beads became defective, and after exerting every effort possible, flue plugs had to be driven in them in cases of emergency (which is not a general practice). During the fourteen months service of this engine the mileage ran up to 43,415 miles, which is not very good for this class of power, as it is of the wide fire-box type, containing 306 2-inch tubes, 15 feet long. As stated above, we have not obtained very good mileage with a steel flue and have not made a success of welding a steel end on a steel flue.

METHOD OF SETTING FLUES.

The method of setting flues in vogue at this place is as follows: After the removal of all flues from a boiler the flue sheet is thoroughly inspected, and if any burr is discovered from excessive calking of flues while in service it is reamed out, after which 40-pound copper ferules are rolled in the sheet to fit the swedge of the flue. I might state here that we have a standard size of swedges which covers all sizes of flue holes from 1 15/16 inches to 2 1/16 inches. The number of swedges together with the length of flue is then given to the flue welder. After receiving the flues they are put in the boiler, mandreled out to the sheet, and expanded with a prosser sectional flue expander. The flue end is then turned over with a device which we have to fit a long-stroke hammer, then rolled lightly, the last procedure being to calk it. We have had very good success with this method of flue setting.

COMPARISON OF IRON AND STEEL TUBES IN SERVICE.

In the last year, on our Colorado division, there has been a series of tests made as to the efficiency of the steel tube on one-half of the flue sheet and iron on one-half of the flue sheet, which has resulted in no difference of service whatever at the furnace end. As to the pitting of the flue or any other defect which might occur in the body of a flue in a boiler, at present I am not in a position to say much, as the flues are still in service. Careful inspection will, however, be made when they are removed, so as to determine their quality.

Increasing the Efficiency of Steam Boilers.

Experiments now being conducted by the boiler division of the United States Geological Survey fuel-testing plant at St. Louis, Mo., on the nature of boiler efficiencies have suggested that stationary boilers should be made to do from ten to twenty times as much work per unit of heating surface as they do now. This great increase in capacity is to be attained by subdividing the heating surface and water streams more finely by allowing less restriction of the water inside the boilers and by using high forced and induced draft to put a large mass of gases through the boiler at a very high speed.

Up to the present time there have been only vague ideas among engineers as to what factors influence the efficiency of the steam boiler so as to cause it to absorb more or less of the heat generated by the combustion. A few years ago Mr. John Perry, a distinguished mechanical and electrical engineer of England, went into the subject mathematically and set forth his general conclusions tentatively in a book on the "Steam Engine and Gas and Oil Engines." About a year ago, the government testing plant took up the mathmematical investigation of the theory of the steam boiler and of heat absorption and extended Mr. Perry's theory somewhat. For some weeks past, Mr. Walter T. Ray, assistant engineer, acting under the supervision of Prof. L. P. Breckenridge, engineer-in-charge of the boiler division, has been conducting a series of experiments on small multi-tubular boilers fed with air electrically heated and so dimensioned as to enable the theory to be either verified, modified or refuted.

Mr. Perry's theory states that modifying conditions being omitted from consideration, every boiler will always absorb by convection from the gases passing through it, the same percentage of heat which could possibly be absorbed by any boiler containing water at a given steam temperature. This efficiency is, therefore, independent of the temprature of the entering gases and of the amount of gases flowing through the boiler. Of course, it must be understood that the above statement of the theory is slightly subject to modification even theoretically and more so in practice. As a practical example, assume that the water in a boiler circulates with entire freedom, which is an unwarranted assumption, and that its temperature is 300 degrees F.; let the gases enter the boiler at 1,300 degrees F., then the difference between the two is 1,000 degrees F., and consequently it would be possible for a boiler infinitely long to reduce the temperature of the gases passing through it to 300 degrees F. Let us assume, however, that the gases leave the boiler at 500 degrees F., which is 200 degrees above steam temperature. The efficiency of the boiler then is 80 percent, because it has reduced the temprature 800 degrees out of a possible reduction of 1,000 degrees. If the same boiler be supplied with gases at 2,300 degrees F., the gases enter the boiler at 2,000 degrees F., above steam temperature. Mr. Perry's theory states that this particular boiler will reduce these gases 80 percent as much in temperature as would a boiler infinitely long; that is to 400 degrees above steam temperature, which is 20 percent of 2,000 degrees, or to 7,700 degrees F. It will be noticed that the mass of gases does not enter into consideration at all.

This surprising deduction is being accurately verified by the aforementioned Division of the Survey, from which it is found, when keeping other conditions the same and when keeping the initial temperature of the gases constant, that the final temperature of the air remains the same, whatever the amount of air sent through the boiler per second. So far the upper limit has not been reached with tubes clean inside and out, although the rate of evaporation has already been pushed up to many times that obtained even in locomotive practice.

Perry's theory takes into consideration four fundamental features affecting heat absorption at any point of the heating surface:

First: Temperature difference between the gases outside any portion of the boiler tube and the water inside.

Second: The number of molecules per cubic inch in the gases outside the boiler tube.

Third: The specific heat of the gases at constant pressure.

Fourth: The velocity of the gases parallel to the heating surface.

Of the four above factors, only the first has usually been considered. It will be readily seen that if we increase the temperature of the gases we decrease the number of molecules beating against any square inch of tube heating surface and thus the second factor largely neutralizes the first, especially at high furnace temperatures.

The third factor can be taken as a constant equal to .24.

The fourth factor is the new and surprising one. Mr. Perry considers that a high velocity of gases parallel to the heating surface scrubs off more or less of the dense film of gases adhering to the metal surface, which film of gases has already become cold by proximity to the metal. The higher the velocity of gases the more the scrubbing effect, and consequently the greater the amount of heat transmitted. This theory necessarily assumes that the ability of the metal to transmit heat is practically infinite, and when we consider that we ordinarily never put through a boiler tube more than 1-1,000 of the heat it could possibly carry, it will be realized that this assumption is warranted.

Mr. Perry's theory and the Survey's verification of it will result in placing the steam boiler on a fairly secure mathematical basis, the same as generators and motors are now on. Thus far the experiments check out the theory excellently.

ARCH TUBES AND BRICK ARCHES.‡

The subject of arch flues is one that was given considerable attention several years ago on the Union Pacific Railroad, in order that we might find out whether or not tubes were fulfilling the claims that were made for them. I understand that the first and most plausible claim is that these tubes assist the circulation of the water, and second that the heating surface is materially increased and so increases the steaming qualities of the boiler.

From my experience with arch tubes, these claims have never been made good. About three years ago, at the suggestion of our general boiler inspector, C. L. Hempel, all arch tubes were ordered taken out as the engines came to the shops for repairs. That order was carried out until, to-day, I do not know of one engine having arch tubes. The water circulates just the same and the steaming qualities of the engine have never been impaired in the least. It cost our company at that time about $75 per engine per year to maintain these arch tubes in addition to the risk of accidents from having these tubes burst or pull out of the hole in the flue sheet. The only advantage we got from these arch tubes was that they assisted in holding the arch bricks in place, but we substituted a stud-bolt with a square end on it and dispensed with arch tubes as a useless expenditure of about $40,000 per year. I might also say that the Union Pacific has no desire to return to the use of arch tubes.

Being now in the service of the Lehigh Valley Railroad Company, I have inquired to what extent arch tubes are being used, and I am unable to find one engine out of our 800 equipped with arch tubes. So, personally, I take my stand with those who say that arch tubes are not necessary in the present locomotive fire-box.

The brick arch opens up quite a large subject, as in order to discuss this, we shall be forced into the subject of heat and combustion. Of course, I believe, as some other boiler makers do, that the brick arch is detrimental to the life of the fire-box, because in our inspection we have always found that most of the cracks on inside sheets are directly under the arch—this is especially true of engines carrying 200 pounds pressure or over.

What is the purpose of the brick arch? That is the question I put to an engineer once, and his reply was that it made the engine steam better. The same question was put to a gentleman whose duties were to go from one end of the line to the other to watch and report the performance of engines in service; his reply was that the brick arch assisted in combustion and was the means of saving a large percentage of coal. His opinion was that there was more money saved in coal than would offset the cost of a new fire-box once every two years. Personally, I am of the opinion that, in order to decide on the question of arches, we must be guided by the quality of coal that is used, also the district in which the engine does service. Some claim that arches protect the flues from cold air striking them, but I do not take any stock in that, as in our experience we have abundant proof from engines that have no arches where the tubes have given better service than those that had arches. I believe, however, that where certain kinds of soft coal are used, brick arches are necessary in order to get the best results.

THOMAS LEWIS.

We have now about one thousand engines equipped with arch tubes and arch brick, and have not made a test of any kind since 1893, at which time we made a test with two engines, one simple and one compound, both narrow fire-boxes, with and without arch bricks. It was plainly demonstrated at that time that, by using arch tubes and arch bricks, there was a saving of fuel better than 10 percent. Since 1893 we have bought all our heavy power, both wide and narrow fire-boxes, all using arch tubes and arch bricks. No tests have been made.

COMPARATIVE COST OF MAINTENANCE OF BRICK ARCHES.

TABLE COMPILED BY JOHN GERMAN.

Engine No.	5001	5009	4664	4670	5729	5718
Class of service	Passenger	Passenger	Passenger	Passenger	Freight	Freight
No. of miles	6,273	9,152	9,063	11,880	10,669	6,938
Cost of brick replaced, account flue repairs	$14.75	$36.96	$22.46	$30.40	$14.76	$12.23
Cost of labor, account flue repairs	.43	1.69	.69	.83	.58	.94
Cost of brick replaced, account defective brick	.90	23.78	12.22	12.32	4.70	1.25
Cost of labor, account defective brick	.10	1.29	.52	.41	.23	.16
Total cost of replacements	$16.19	$63.72	$35.89	$43.96	$20.27	$14.58
Cost maintaining arch per 1,000 miles	2.50	6.96	3.96	3.70	1.89	2.08
Total tons of coal used	330.6	465.5	479.4	594.	1132.	795.1
Tons of coal used per 1,000 miles	52.70	50.86	52.88	50.	107.1	116.
Cost coal per 1,000 miles at $1.62 per ton	$85.38	$82.39	$85.66	$81.00	$173.50	$187.92
*9% of coal per 1,000 miles	7.68	7.42	7.71	7.29	15.61	16.91
Net amount saved—by use of brick arch per 1,000 miles.	5.18	.46	3.75	3.59	13.72	14.83
Cost of maintenance of arch, in percentage of cost of coal	2.9%	8.4%	4.6%	4.5%	1.09%	1.1%

Average cost of maintenance of standard arches per 1,000 miles equals	$3.01
Average cost of maintenance of hollow arches per 1,000 miles equals	4.52
Average cost of maintenance of all arches per 1,000 miles equals	3.51

COST OF COMPLETE NEW BRICK ARCHES.

Kind of Arch.	Class of Engines.	Cost of Material.	Cost of Labor.	Total Cost.	Am't Hollow Arch Cost Over Standard.
Hollow	F51 & G42 A. & B.	$9.24	$0.23	$9.47	$4.45
Standard	†F51 & G42 A. & B.	4.92	0.10	5.02	....
Hollow	J40C	14.53	0.30	14.83	6.47
Standard	J40C	8.18	0.18	8.36	....

JOHN GERMAN, G. B. I.
L., S. & M. S. Ry., Elkhart, Ind.

*9 percent. represents net amount coal saved by use of arch over no arch.

† Cost of hollow arch does not include cost of combustion tubes in fire box or cost of labor of putting same on.

‡ Reports Presented by the Committee on Arch Tubes and Brick Arches, at the Boiler Makers' Convention in May.

We are expending, annually, for arch tubes and arch bricks $50,000, which is the first cost. For applying and renewing it costs us about $50,000 more. Figuring that our fuel bill is $5,000,000 and that we are saving 10 percent by using arch bricks and arch tubes, we have to our credit $400,000 after deducting the cost of applying and renewing arch tubes and arch bricks.

We have also a number of engines equipped with the hollow arch brick, which we are testing out at present. These are showing up better results than we are getting from the solid arch.

I will also state that we are getting from our heaviest power, freight and passenger, from 24 to 36 months' service between full flue renewals, making from 100,000 to 230,000 miles. In 1904 we applied 12 fire-boxes on the system; in 1905, 8 fire-boxes; in 1906, 8 fire-boxes. This shows that we are getting fair service from our flues and fire-boxes.

I have recently had a statement from the Santa Fe, also from the Pere Marquette Railroad, who have been making a practical test with no arch, solid arch and hollow arch. They show a saving better than 5 percent with solid arch over no arch, a saving of better than 20 percent with hollow arch over no arch. The abatement of black smoke expressed in terms of percent of the elimination, hollow arch over no arch, in freight service, 65 percent; in passenger service, 76 percent.

The only point against using arch tubes is the liability to open in the seam, on account of defects or rupture on account of accumulation of mud. If this is looked after closely, there will be but very few cases of this kind.

In using arch brick, we are unable to clean out flues or to calk flues when leaking slightly, and a great many times we let them go. This is to save taking out arch brick. An engine is undoubtedly held out of service much longer on account of having arch brick, when there is fire-box or flue work to do, as the engine must be cooled down and the arch taken out before the boiler work can be done. If there was no arch, steam could be blown off and the boiler work done, and the engine again put in service very quickly. These are perhaps the important points against using arch brick.

A. N. LUCAS.

Liquid Chalk.

A very handy thing to have on the bench where there is much work to lay out on castings or sheet iron, is a solution made of chalk, glue and water. Take a pint can and powder enough chalk to fill it two-thirds full, then fill it almost full of clean, hot water and add about two tablespoonfuls of liquid glue and mix thoroughly while it is hot. This is much more handy than chalk, as you can put it on with a brush the same as paint. It will not rub off in handling and gives a nice surface to work on. The chalk must be powdered very fine or it will be rough when dry.

The members of the new Board of Boiler Rules, recently appointed by the Governor of Massachusetts, are as follows: Chairman, Mr. Joseph H. McLeill, of Melrose, of the Massachusetts Boiler Inspectors' Department; Mr. William M. Beck, of Everett, operating engineer; Mr. John A. Stephens, of Lowell, chief engineer of the Merrimac Manufacturing Company; Mr. Frederic H. Keyes, of Newton, general manager of the Robb-Mumford Boiler Company, and Mr. Robert J. Dunkle, representing boiler inspector's interests.

According to the census reports 8 of the 4,834,000 women who are wage earners in this nation are working as boiler makers, 185 as blacksmiths, 508 as machinists, and 45 as engineers and firewomen.

Boiler Manholes and Handholes.

BY R. T. STROHM.

Every steam boiler must be subjected to periodical cleanings, both inside and outside, in order to maintain its proper condition with regard to safety and efficiency of operation. For internal inspection and cleaning some means of access to the inside of the boiler shell or drum is necessary. Consequently, boilers are fitted with manholes and handholes.

The location of manholes in a boiler shell should be such as to afford easy access to those parts requiring care and attention. In the plain cylindrical boiler the manhole is placed in the head, which is usually bumped to make it self-supporting.

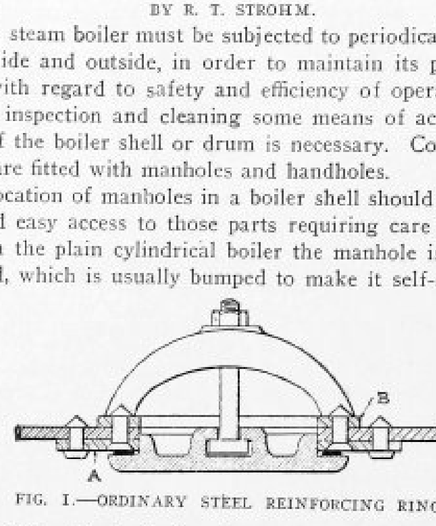


FIG. 1.—ORDINARY STEEL REINFORCING RING.

In the return tubular boiler there are usually two manholes, one being placed in the front head, below the tubes, and the other in the middle plate of the shell above the tubes, and at the highest point of the shell. The lower one enables the inspector to examine the plates that are in contact with the furnace gases in operation, while the upper one permits him to inspect the condition of the braces and stays. In the case of water-tube boilers, a manhole is placed in the head of the steam drum, or in the head of each, if there are several drums.

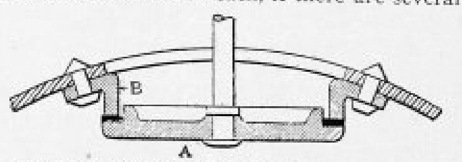


FIG. 2.—CAST IRON REINFORCING RING ON INSIDE OF SHELL.

In boilers of the vertical type the manhole is placed in the side of the central main drum, near the bottom, as in the "porcupine" boiler; or it may be omitted altogether, as in various other makes in which there is no necessity of entering to make examination of the condition of the shell, or in which the steam space or the water space are not large enough to admit a man. Handholes should be placed wherever deposits of sediment are likely to occur, if these deposits cannot be easily removed through the nearest manhole. They are located in the water legs of vertical and locomotive boilers, in the heads

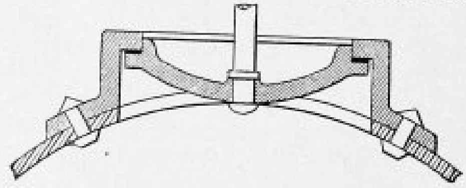


FIG. 3.—CAST IRON REINFORCING RING ON OUTSIDE OF SHELL.

of return-tubular boilers, and in the headers of water-tube boilers, opposite the ends of the water tubes, to which they give access.

The size of the manhole varies a little among manufacturers of boilers, but the average size is about 12 inches by 15 inches, the hole being elliptical in shape. Handholes are also elliptical, but they vary in size to a much greater extent than manholes. Thus, handholes may be found 9 inches by 14 inches, or 8 inches by 12 inches, and down to the common opening 4 inches by 6 inches, depending upon the size of the boiler and the location of the hole. The handholes opposite the ends of water-tubes in water-tube boilers are generally circular, especially when each tube has its own individual handhole. In case one hole gives access to two tubes it is made oblong.

The cutting out of a section of the shell to give the manhole opening weakens the boiler, since it takes away a portion of the plate which would otherwise aid in resisting the forces set up by the internal pressure. Now, there is a greater pressure per inch of longitudinal seam than per inch of girth seam. That is, the boiler is more liable to rupture by splitting in a longitudinal direction than by tearing apart circumferentially. Hence, it is desirable to remove from the shell as little as possible of the metal which would strengthen the boiler along the line of greatest stress. For this reason the manhole opening is so placed that its shorter axis or dimension is parallel to the longitudinal axis of the boiler, as in this position the shell is weakened least. In case the manhole is placed in one of the heads its longer axis is horizontal, in order to enable a man to enter easily and not because the head is stronger with the hole in this position than it would be with the longer axis vertical.

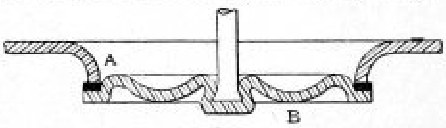


FIG. 4.—REINFORCEMENT OBTAINED BY FLANGING THE HOLE.

To compensate for the loss of strength due to the cutting away of the plate, it is customary to use reinforcing rings or their equivalent. The reinforcing ring is simply a flat ring of metal riveted to the shell around the edge of the opening. The net section of this ring is made of such extent that its tensile strength will be at least equal to the tensile strength of that part of the plate cut away along the short axis.

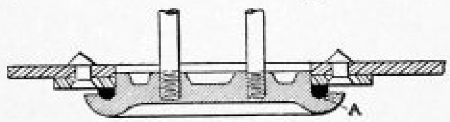


FIG. 5.—COVEER SECURED BY STUD BOLTS.

The reinforcing ring may be made of gun metal, wrought iron, cast iron or steel. The use of cast iron is not to be commended, however, for this ring must safely withstand stresses which tend to tear it into halves, and in tension cast iron is a very unreliable and treacherous material. An ordinary form of reinforcing ring, made of wrought iron, is shown at *A*, in Fig. 1. It is riveted to the inside of the shell by a double row of rivets, the row next the edge of the hole being countersunk so as to give a flat surface upon which the gasket may rest. Frequently an additional ring is used on the outside, as at *B*. In case two rings are used, their combined strength should be equal to or greater than that of the plate section removed.

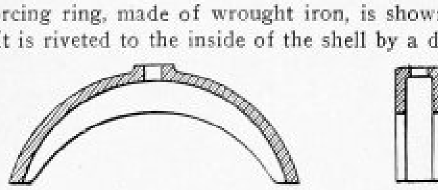


FIG. 6.—COMMON FORM OF YOKE.

If a cast iron frame or ring is used it may have the form shown in Fig. 2, where the ring is shown placed on the inside of the shell. When the boiler is under pressure, the manhole cover *A* is pressed outward against the lip *B*, putting a compressive stress on the frame. Cast iron being very strong in compression, this is the safest form of frame made of this material. The fact that it is in tension laterally is the objection to its use. Another form of cast iron frame but riveted to the outside of the shell, is illustrated in Fig. 3. In this style the metal is in tension in both directions; hence, the outside cast iron frame should be avoided as far as possible. In a number of instances outside frames of this shape are made of gun metal or wrought steel, these materials being amply strong in tension. Another method of reinforcing manhole openings which is widely used is illustrated in Fig. 4. It is done by cutting the hole in the plate considerably smaller than the finished opening desired, and then flanging the edge, turning the plate inward, as at *A*, after which the edge is faced off nicely to form a bearing for the manhole cover. The ring of plate thus curved inward is relied upon to strengthen the plate properly.

Usually handholes are comparatively small in size, and for that reason no reinforcing ring is used in many cases, the handhole plate bearing directly against the plate. In the case of very high pressures, or very large handholes, a single ring may be riveted outside the plate to compensate for the loss of strength due to the removal of material.

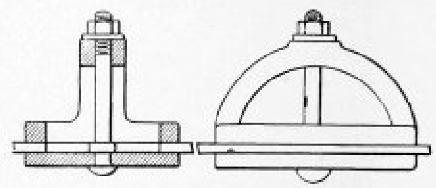


FIG. 7.—YOKE FOR HAND-HOLE WITHOUT REINFORCING RING.

The covers of manholes and handholes are generally made of cast iron, and they are held in place by the internal pressure when the boiler is under steam. However, it is necessary to have some means of securing them under all conditions, and so each plate is fitted with one or two bolts and yokes. These may be stud bolts, screwed into the cover, as in Fig. 5, or the plate may be drilled and the bolt riveted in place, as in Fig. 2. Another method, quite as common as either of the foregoing, is to cast the cover plate with a slot into which the head of the bolt is slipped, as illustrated in Fig. 1.

A form of cover plate which may be made either of wrought iron or steel is illustrated at *B* in Fig. 4. It consists of a piece of sheet metal which is formed to the desired shape by dies, under heavy pressure. The bolt fits into the dovetail slot at the middle, and cannot be pulled out by any ordinary force. This style of cover is very light, and as it is made of rolled material there is little chance of flaws being present, which cannot be said of a cast iron plate. The corrugations act as strengthening ribs, preventing buckling of the cover when under pressure.

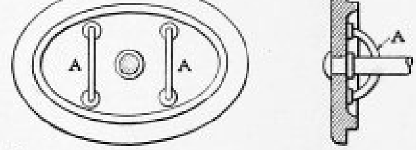


FIG. 8.—HANDLES FOR PLACING A HEAVY COVER.

The yokes by which cover plates are held in place are made of cast iron to a great extent. In case the cover is of the form shown in Fig. 4, however, the yoke is made of the same material, being of the shape shown in Fig. 6; like the cover it is formed by dies from a piece of flat plate. Where handholes are not reinforced it is not uncommon to find the yoke made so as to bear along the entire perimeter of the hole, as illustrated by Fig. 7, instead of at several points, as in the case of the ordinary yoke.

An ordinary cast iron manhole cover has considerable weight, and it is no easy matter to hold it in place, and at the same time adjust the yokes and the bolts. To aid in placing it wrought iron loops or handles are frequently cast in the plate, by which it may be held and adjusted; the shape and location of these rings is usually as shown at *A*, *A*, in Fig. 8. The comparative lightness of the plate shown in Fig. 4 makes it unnecessary to provide any handles, which is another advantage possessed by this type of cover.

Although the total steam pressure on a manhole or handhole cover plate is considerable, it is not sufficient to maintain a tight joint between the cover and the main shell. To prevent leakage here gaskets of various materials are used. In Fig. 5 is shown the method of applying the gasket to the form of joint there indicated. A shallow recess is cast in the cover plate, into which is fitted a ring of gasket material of circular

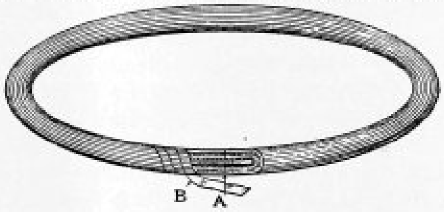


FIG. 9.—GASKET SHOWING JOINT MADE WITH TAPE.

cross-section. When the yokes are put in place and the nuts tightened the cover is drawn up against the reinforcing ring, flattening the gasket as at *A* and making a tight joint.

A form of gasket widely used for this purpose is shown in Fig. 9. It is practically a heavy cord, made up of alternate layers of cotton duck and rubber, with a core of soft wire. It is sold in long coils, from which a sufficient length is cut when

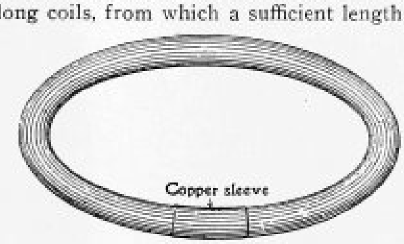


FIG. 10.—GASKET SHOWING JOINT MADE WITH COPPER FERRULE.

a joint is to be made. This piece is bent to fit the manhole plate, then its ends are cut so as to match nicely, as at *A*, and the joint is wound with tape, as at *B*, making a continuous gasket. Another style of gasket of somewhat similar construction consists of a small tube of Para rubber containing an insertion of brass wire gauze. This combination is encased in another layer of ordinary gasket rubber. Instead of wrapping the joined ends with tape, however, a short annealed copper sleeve or ferrule is employed, into which the ends of the piece are forced until they meet, making the joint appear as in Fig

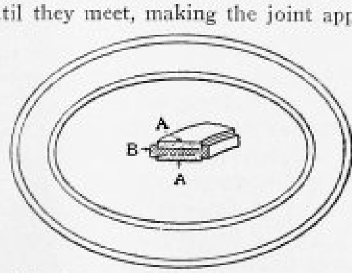


FIG. 11.—SPECIAL FORM OF GASKET.

10. The material for these gaskets varies from ⅛ inch to ⅝ inch for handholes and manholes, and may be obtained as large as 1 inch in diameter for extra large joints.

In case the flange of the plate or that of the reinforcing ring extends inwards, as in Figs. 2 and 4, to form a bearing for the cover, there is some danger of squeezing out the gasket. A form designed to prevent this action is illustrated in Fig. 11. It consists of two flat rings of rubber *A*, *A*, between which is a soft metal ring of *I* section. The lugs on the metal ring prevent the rubber from being squeezed out entirely when the gasket is under pressure. The usual type of gasket, such as is used in connection with the manhole covers shown in Figs. 1, 2 and 3, is made of asbestos, rubber, rubber and copper or metal alone.

If so desired, the cover plate may be made as shown in Fig. 12. A groove is cast in the flange, into which soft metal is poured and hammered. Owing to its plastic nature this metal forms a good joint when the cover is properly drawn

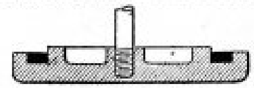


FIG. 12.—COVER WITH SOFT METAL GASKET.

up, while the depth of the groove which holds it prevents its being squeezed out or blown out by the steam pressure.

In most boilers it is necessary to remove and replace the handholes and manholes frequently, and therefore the gaskets should be of such form as not to be easily destroyed by repeated breaking of the joints. It is well to give the gasket a coat of oil and graphite after it is put in place on the cover, so that when the joint is broken the gasket will not stick to the boiler shell. In replacing the cover, care should be taken to put it back in the same position that it occupied before it was removed, so that the same surfaces meet, in order to prevent leakage.—*American Electrician.*

Rules and Regulations Prescribed by the British Board of Trade for the Inspection and Construction of Steam Boilers.

(Continued from July issue.)

STEEL BOILERS.

The breadth of test strips for tensile stress should be, where practicable, 2 inches, and the elongation taken in a length of 10 inches, should be about 25 percent, and not less than 18 percent when the strips are tested in the normal condition, in which condition the board prefer the tests to be made; but if the plates are annealed, that is, heated to a red heat in a *plate* furnace, and immediately they are at that heat taken out and placed on the mill floor to cool, the elongation should not be less than 20 percent. The test pieces must not be annealed after they are cut off the plates. When the plates are not taken out of the furnace immediately they are red hot, or if allowed to cool down in the furnace, or are covered with ashes or other non-conducting substance, it should be reported to the board for their consideration and decision. The surveyor should report to the board whether the plates were annealed or in the normal condition when the test pieces were cut off. The test strips must be carefully prepared and measured, and, where practicable, they should be cut from the plate by a planning or shaping machine.

The surveyor should see that the plates for the manhole doors and for the compensating rings around the openings for the doors are tested in the usual manner.

The bending test for plates *not* exposed to flame should generally be made with strips in the same condition as the plates, but occasionally some tempering tests should be made. Strips cut from furnaces, combustion boxes, etc., and also those plates which will be worked in the fire, should be heated to a cherry red, then plunged into water at about 80 degrees and kept there until of the same temperature as the water, and then bent. The bending and tempering strips should be about 2 inches broad and 10 inches long, and they should be bent until they break, or until the sides are parallel at a distance from each other of not more than three times the thickness of the plate.

When full allowance over iron is wished, the tensile strength of the plates *not* exposed to flame should be not less than 27 tons, and should not exceed 32 tons per square inch of section, and 27 tons should be the stress used in the calculations for cylindrical shells if the plates comply with all the conditions as stated herein, but for each ton the minimum tensile strength of the plate is above 27 tons, 1 ton may be added to the 27 used in the calculations, provided the surveyor witnesses the testing of *all* the plates. The tensile strength of furnace, flanging and combustion box plates may range from 26 to 30 tons per square inch.

The following proportion of stay and rivet bars should be tested in the surveyor's presence for tensile strength and elongation, viz.: one bar in 20 when the diameter of the bar does not exceed 1 inch; one bar in 12 when not over 1½ inches; and one bar in 8 when the diameter exceeds 1½ inches. When the number of bars of any one size in the order exceeds the number for which the surveyor is required to make one test, but is less than double that number, he should make two tests from bars of that size.

The tensile strength of stay bars should be from 27 to 32 tons per square inch, with an elongation of about 25 percent and not less than 20 percent in a length of 10 inches. Solid steel screwed stays may be allowed a working stress of 9,000 pounds per square inch of net section, provided the tensile strength and elongation are as stated. Steel stays which have been welded should not be passed. (This does not apply to stay tubes which are welded longitudinally.)

Solid steel stays for supporting dished ends, which are found to be equal to the pressure needed when considered as portions of spheres, may have a nominal stress of 18,000 pounds per square inch of net section.

The tensile strength of strips to form stay tubes should be from 26 to 30 tons per square inch, with an elongation of about 25 percent, but not less than 20 percent in a length of 10 inches. Stay tubes made of steel which complies with this requirement, may be allowed a stress not exceeding 7,500 pounds per square inch of net section, providing their net thickness is in no case less than ¼ inch.

The tensile strength of rivet bars should be from 26 to 30 tons per square inch with an elongation of not less than 25 percent in a length of 10 inches. Although the surveyors are not required in every case to see the rivets tested, they should frequently select a few at the boiler maker's works, mark them and see them tested. Rivets before being tested should be carefully prepared, and the elongation should, when practicable, be taken in a length of two and one-half times the diameter of the prepared part. The tensile strength of the rivets should be from 27 to 32 tons per square inch, and the contraction of area about 60 percent.

If test pieces require to be reduced in size before testing, it must be done in a lathe or by machine; test pieces should not in any case be prepared by heating and drawing down.,

Surveyors who attend at steel works or elsewhere to witness the tests of material for boilers, should see that all plates and bars in the order are properly stamped with an identification number.

Perforating and Annealing.—It is expected that the rivet holes in furnace and shell seams will be *drilled*, but if it is wished to punch them and afterwards either bore out the holes or anneal the plates, the particulars of the punching and boring or annealing should be submitted to the Board of Trade for consideration before being done, but all punching should be done after bending.

In all cases where assent has been given for plates to be punched after bending and then annealed, the makers should stamp the plates with the words, "punched after bending and then annealed," and in all cases where assent has been given for punching and afterwards boring plates the words "punched and then bored" should be stamped on the plates.

If flanged plates and plates exposed to flame comply with the foregoing conditions, the constants in the board's rules for iron boilers may be increased as follows:

The constants for flat surfaces when they are supported by stays screwed into the plate and riveted, 10 percent.

The constants for flat surfaces when they are supported by stays screwed into the plate and nutted, or when the stays are nutted in the steam space, 25 percent. This is also applicable to the constants for flat surfaces stiffened by riveted washers or doubling strips, and supported by nutted stays.

The constants for combustion box girders, 10 percent.

The constants for plain furnaces, 10 percent.

Furnaces.—Machine-made furnaces of the Fox, Morison or Deighton corrugated types, manufactured by the Leeds Forge Company; John Brown & Company, Sheffield; the Deighton Patent Flue & Tube Company, Leeds, and William Beardmore & Company, Glasgow; of the Purves ribbed and grooved type, or Brown's cambered type, manufactured by John Brown & Company, Sheffield; and of the Fox or Morison corrugated type, manufactured by Thomas Piggott & Company, Birmingham, provided they are practically true circles and the plates are not less than 5/16 inch thick, may be allowed the working pressure found by the following formula:

$$\frac{C \times T}{D} = \text{working pressure.}$$

C = *14,000.

T = thickness in inches, measured at the bottom of the corrugation or camber.

D = outside diameter in inches, measured at the bottom of the corrugations or cambers when the furnace is of the corrugated or cambered type, or over the plain parts, when it is of the ribbed and grooved description.

In the Fox furnace the pitch of the corrugations should not exceed 6 inches, and in the Morison furnace and the Deighton furnace the pitch should not exceed 8 inches. In these descriptions of furnaces the depth from top of corrugations outside to bottom of corrugations inside should not be less than 2 inches.

The ribs of ribbed and grooved furnaces should not be less than 1 5/16 inches above the plain parts, the depths of the grooves not more than ¾ inch, and the length between the centers of the ribs not over 9 inches. In Brown's cambered furnace the thickness of metal at the center of the ribs should be at least 3/16 inch greater than the thickness at the bottom of the camber, the tops of the ribs should be curved to a radius of 1¾ inches and the grooves beneath the ribs to a radius of 45/64 inch, the height of the ribs above the bottom of the camber should not be less than 1⅝ inches and the pitch of the ribs should not be more than 9 inches.

Machine-made furnaces of the bulb type manufactured by the Leeds Forge Company may be allowed the working pressure found by the following formula, provided they are practically true circles, that the pitch of the bulbs does not exceed 8 inches, that the depth from the top of the bulbs to the plain parts at the center of the pitch is not less than 2¼ inches, that the plates are not less than 5/16 inch thick and the plain parts between the bulbs are fairly uniform in thickness:

$$\frac{15{,}000 \times T}{D} = \text{working pressure.}$$

T = thickness of the plain parts between the bulbs in inches.

D = outside diameter at the middle of the plain parts between the bulbs in inches.

* This constant only applies to furnaces of the types named when made by the firms given in the preceding part of this paragraph. The surveyors should continue to report full particulars of any case in which the owners or builders of a passenger steamer propose to use furnaces of any of these types if made by other makers.

In each of these descriptions of furnaces the plain parts at the back ends should be so made that the length, measured from the waterside of the back tube plate to the center of the back end corrugation or rib, does not exceed 9 inches. The plain parts at the front ends should also be so made that the length of the flat, measured from the center of the rivets by which the furnace is secured to the front end plate, does not exceed 9 inches. When the plain parts at the back ends are made conical, and the flange by which the attachment is made to the back tube plate is continuous, a length of 10½ inches may be allowed between the waterside of the back tube plate and the center of the first corrugation or rib. When this method of construction is adopted, the vertical section through the neck-piece should be kept as circular as is practicable, the set-up at the bottom should not exceed 8 inches measured over the plates, and in no case should the vertical axis exceed the horizontal one by more than 14½ percent. The plates at the ends should not be unduly thinned in the flanging.

If the furnace is riveted in two or more lengths the case should be submitted for consideration.

When horizontal furnaces of ordinary diameter are constructed of a series of rings welded longitudinally, and the ends of each ring flanged and the rings riveted together, and so forming the furnace, the working pressure is found by the following formula, provided the length in inches between the centers of the flanges of the rings is not greater than $(120\ T - 12)$, and the flanging is performed at one heat by a suitable flanging machine, and also the conditions which follow the formula are complied with:

$$\frac{9{,}900 \times T}{3 \times D}\left(5 - \frac{l + 12}{60 \times T}\right) = \text{working pressure.}$$

T = thickness of plate in inches.
l = length between center of flanges in inches.
D = outside diameter of furnace in inches.

The radii of the flanges on the fire side should be about 1½ inches. The depth of the flanges from the fire side should be three times the diameter of the rivet plus 1½ inches, and the thickness of the flanges should be as near the thickness of the body of the plate as practicable. The distance from the edge of the rivet holes to the edge of the flange should not be less than the diameter of the rivet, and the diameter of the rivet at least ⅜ inch greater than the thickness of the plate. The depth of the ring between the flanges should be not less than three times the diameter of the rivets, the fire edge of the rings should be at about the termination of the curve of flange, and the thickness not less than half the thickness of the furnace plate. It is very desirable that these rings should be turned.

The holes in the flanges and rings should be drilled in place if practicable, but if not drilled in place they should be drilled smaller than the size required, and afterwards when in place reamed out until the holes are quite fair, the holes should be slightly tapered and the heads of the rivets of moderate size.

After all the welding, flanging and heating is completed each ring should be efficiently annealed in one operation.

When the flanges of the back ends of the furnaces are not continuous, and the lower parts of the back rings are supported by substantial T-bars securely riveted to the plates, the constant used for these rings should not exceed .9 of that given in the formula.

Compressive Stress on Tube Plates.—A greater compressive stress should not be allowed on tube plates than 14,000 pounds, which is that used in the following formula:

$$\frac{(D - d)\ T \times 28{,}000}{W \times D} = \text{working pressure.}$$

D = least horizontal distance between centers of tubes in inches.
d = inside diameter of ordinary tubes in inches.
T = thickness of tube plate in inches.
W = width of combustion box in inches between the tube plate and back of fire-box, or distance between the combustion box tube plates when the boiler is double-ended and the box common to the furnaces at both ends.

Plate and Rivet Section.—When the minimum tensile strength of the shell plates is S tons and full allowance is wished the rivet section, if iron, in the longitudinal seams of cylindrical shells should, when those seams are lapped, be at least s/17.5 times the net plate section, and if steel rivets are used their section should be at least s/23 of the net section of the plate if the tensile strength of the rivets is not less than 27 tons and not more than 32 tons per square inch. In calculating the working pressure, the percentage strength of the rivets may be found in the usual way by the board's rules, but in dealing with iron rivets the percentages found should be divided by s/17.5, and in the case of steel rivets by s/23, the results being the percentages required. If the percentage strength of the rivets is found by calculation to be less than the calculated percentage strength of the plate, the working pressure should be calculated by both percentages. When using the percentage strength of the plate 4.5 plus the additions suitable for the method of construction as by the board's rules for iron boilers, may be used as the nominal factor of safety, but when using the percentage strength of the rivets 4.5 may be used as the factor of safety. The less of the two pressures so found is the working pressure to be allowed for the cylindrical portion of the shell.

Local Heating to be Avoided.—Local heating of the plates should be avoided, as many plates have failed from having been so treated.

Annealing.—All plates that have been punched, flanged or locally heated, also all stays and stay tubes which have been locally heated should be carefully annealed after being so treated.

Welding.—Steel plates which have been welded should not be passed if subject to a tensile stress, and those welded and subject to a compressive stress should be efficiently annealed.

Steel tubes made by the Mannesmann process need not be objected to for use in boilers, provided the material and the tests comply in all respects with the board's usual requirements.

In other respects the boilers should comply with the rules for iron boilers.

If the tests are to be made at the steel works the boiler makers should inform the surveyors in their district when and where they will be made, so that a surveyor from the nearest district to the steel works may be instructed to attend to them. The surveyors should have due notice—two or three days—when the plates, etc., will be ready for the test pieces to be cut from them. As soon as possible after tests are made, the results should be submitted for the board's consideration. (Surveyors should report all cases of failures of steel plates, etc., which may come to their knowledge.)

Steel for Superheaters.—If steel is proposed to be used for the heating surfaces in superheaters the particulars should be submitted to the Board of Trade for consideration, but in all cases it should be discouraged for this purpose. This applies to the unshielded uptakes of all boilers including ordinary vertical donkey boilers.

The annual convention of the American Boiler Manufacturers' Association of the United States and Canada will be held at Atlanta, Ga., October 8, 9 and 10.

The Ageing of Mild Steel.*

BY C. E. STROMEYER.

When, in 1885, I experimented on the effect which was produced in steel by working it at a blue heat, it was expected that this wrong treatment in the workshops would explain many mysterious failures, but I soon went through an experience which left no doubt but that brittleness could be produced by other causes. In 1889, while engaged in testing steel at some German works, I wished to experiment on some basic steel, and, not without some trouble, the manager finally consented to roll a plate out of one of their basic Bessemer ingots. Two strips were at once sheared from this plate, one was bent cold, and the other after tempering. The results were satisfactory, being in agreement with those for the other steels with which I was then dealing. The plate was therefore duly marked off and sheared into strips, and a few days later a series of tests was commenced. They were to have demonstrated whether or not the quality was uniform and trustworthy under punching, bending and other tests. To my surprise the earlier results were reversed, and all the samples proved to be brittle, no matter from what part of the plate they were taken, or rather, each strip now seemed to contain brittle zones extending about ½ inch from the sheared edges. The centers of the test pieces, being still tough, bent fairly well. Further samples which were tested six weeks later were quite brittle.

The idea that steel might go through an ageing process was scouted by all to whom I mentioned it, but experiences accumulated which strengthened my belief in this possibility. Amongst these I may mention that a boiler maker bought an old boiler which he had built years ago, and of which he knew for certain that the furnaces were of Lowmoor iron. He hoped that this material, which was still in request, might come in useful for repair jobs, but, very much to his disappointment this iron had lost its excellent qualities; it was not exactly brittle, but tended towards red shortness and cold shortness. This result is confirmed by a sample from an iron boiler fifty-one years old. This change might have been brought about by contact with the furnace gases, more particularly by the sulphurous fumes. Therefore, on again visiting some steelworks I tied together about half-a-dozen sets of samples, including both the mildest and hardest qualities of boiler steel, and exposed them to hot gases. One parcel was suspended inside a boiler, two others in various parts of boiler flues, two in the flues of a puddling furnace—one was exposed to the atmosphere, and one was tested at once by alternate bending. The others were tested in the same way, but about two months later. However, there was no marked deterioration in any one lot. Time, therefore, and not noxious gases seemed to be the determining factor.

About this time several old wooden armorclads were being dismantled in the Victoria Docks, and much to my surprise the iron armor-plates were being broken up like cast iron, or rather like stone flags under a falling weight. Judging by the severity of the original Admiralty tests on iron armor-plates, one could not help feeling that here, too, an ageing effect had taken place.

My attention was also drawn to the tendency of solid drawn brass tubes to grow brittle and split lengthways; and recently C. Deigel[1] has also drawn attention to this defect, but without suggesting a cause, though this is generally believed to be an insufficient reduction in the drawing process.

The very opposite effects have also been noticed. Manganese steel, like pitch, lowers its elastic limit after straining, helical springs sometimes lose their elasticity, and galvanized steel wire sometimes loses part of its tenactity. According to Sheffield steel makers, whose traditions reach back a few generations, steel improves by keeping, even as regards forging qualities, while spring and instrument makers prefer to use steel which has been stocked for a long time. No reason has been assigned for these beneficial changes; but there does seem to be a possibility of a difference of behavior between steel which has been allowed to cool before reheating and rolling, and another lot which has been placed in a soaking pit and has never entirely lost its casting heat. The molecular changes which take place during cooling and reheating may certainly be expected to differ from those which take place during a single long-continued heat. Now, when speaking of the ageing of a material, one may imagine that either an improvement or a deterioration is taking place; but much will depend on the point of view from which this statement is made. When thinking of structures or machinery, any tendency of a material to grow brittle would be classed as deterioration, and loss of elasticity or increased plasticity would, within limits, be deemed an improvement. On the other hand, when thinking of an elastic spring, loss of elasticity and a tendency to become plastic would be looked upon as deterioration. It may, therefore, be as well to view the changes which can be effected by time merely as an ageing process, without seriously qualifying its relation to the various purposes to which the material might be applied. Then, several phenomena which occur in physics and in chemistry will appear to throw some light on this subject. It is, for instance, well known that sulphur can be made elastic by pouring it into water, and, according to a recent experiment, it can even be converted into a fluid substance by pouring it, when molten, into an intensely cold liquid. Both forms of sulphur, however, become brittle if left to themselves. Possibly, but this has not been established, brittleness has to be initiated either by the introduction of a crystal, or by application of a stress, like the application of a shearing stress to the edges of the steel plates, as mentioned above.

Related phenomena are, crystallization of supersaturated solutions of salts, notably sulphate of soda. The solution is a perfectly homogeneous one, but on introducing a crystal, and thereby relieving or initiating a strain in the fluid, sudden segregation of part of the salt takes place. The well-known sudden solidification of molten phosphorus is a similar phenomenon. The slow changes which take place in solutions of carbonate of soda are analogous to some eutectic phenomena in solid metals, and may help to an understanding of this difficult subject of ageing. At 10 degrees C. 100 grams of water will dissolve 37 grams of sodium carbonate, provided it is asosciated with seven equivalents of water, and has crystallized in rhombohedric form. Another salt, also containing seven equivalents of water, but of rhombic form, will, at 10 degrees C., only dissolve at the rate of 26.3 to 100 of water. A distinct ageing effect can here be noticed, for apparently the former of these salts, although dissolved, slowly changes into the latter form; and if there is more than 26.3 percent present slow precipitation of the surplus salt takes place. The seven-equivalent rhombic salt while in solution can also associate itself with another 3 percent of water, whereby it converts itself into a salt of which at 10 degrees C. only 12.6 parts can be dissolved by 100 of water. Thus, slowly and without apparent cause, soda segregates or crystallizes out of a solution which was certainly not super-saturated. Here we have a case in which time alone produces changes in the constituents of a fluid, which, if it were a solid, would become evident under the microscope as changes of structure.

Similar solution-phenomena have been detected with regard to bromine, calcium chloride, chromate and sulphate, cadmium chloride, cerium sulphate, cobalt iodate, magnesium sulphate, sodium carbonate, sodium sulphate, nickel iodate, zinc chloride

* From a paper presented before the Iron and Steel Institute.

[1] Ver. d. Vereines zur Beforderung des Gewerbfleisses, Berlin, 1906, page 177.

and zinc sulphate. There are certain substances—for instance, silicas and stannic oxide—which, when once precipitated, will not redissolve even when the water is boiled. Such processes may possibly lie at the root of some strange experiences that steel improves with age.

Mild steel being now recognized as a complex solid solution of ferrite, pearlite and other compounds, which may be adulterated with phosphorus, sulphur, etc., and are capable of undergoing slow molecular changes, should not be treated as in the past, as being absolutely stable at ordinary temperatures, more especially as there can be no doubt that severe stresses produce continuous changes of shape. Thus armor-plates emit singing noises for a long time after they have been fired at, and sometimes crack spontaneously when left to themselves. Shells for guns used to crack months after they were hardened. Many flanged boiler plates have cracked while lying idle; test pieces not infrequently crack long after they have been bent. Probably the best illustration of ageing is given by mild steel which has been bent at a blue heat. This subject will be referred to later, but it may here be mentioned that, at a blue heat, mild steel 7/16 inch thick can be bent about two to five times through an angle of 45 degrees. With certain qualities of steel it was found that if the samples were bent through a single angle of 45 degrees and then allowed to rest, they soon became absolutely brittle, and broke with a single blow of the hammer.

Shortly after the experience referred to above with a basic Bessemer steel plate, my attention was drawn to a shell plate of a marine boiler, which had burst under the maker's hydraulic test of 180 pounds per square inch, though designed for a pressure of 150 pounds by the Board of Trade rules. I obtained a piece, as shown in Fig. 1, and marked *CC*. It was 5 feet 4 inches wide, including the rivet holes in the circumferential seams, 11 inches long from the longitudinal fracture to the newly sheared edge, and 1 inch thick. It was sent to Messrs. John Brown & Company, Ltd., Sheffield, and rolled down to ⅝ inch thickness, and would now have a length of about 27 inches. It was cut in three, and two of these strips were each sheared into thirteen test strips, as shown in Fig. 2. The plate was turned over with each shearing, so that both sheared edges of each piece were turned either up or down. This is indicated by the dotted lines in Fig. 2. All the subsequent bending was done with the fins on the inner curvature.

The samples *H* were bent at 212 degrees F., with a view to ascertaining whether the material would be more brittle under steam than when cold, and the samples *F* were bent while very cold, as it had been found that, at any rate, bad steel is most brittle when cold.

Samples marked *I* were dealt with on Feb. 19, 1891, immediately after shearing, and all bent double, though No. 1 (after freezing) cracked.

Five days later, on Feb. 24, 1891, samples marked *II* were bent double, but No. 15 (after freezing) broke. After waiting fourteen days, on March 6, 1891, samples marked *III* were bent. No. 4 bent nearly double, and broke in two places. No. 10 broke with a slight curvature at an angle of about 20 degrees; both had been in the freezing mixture. None were bent at the ordinary temperature, and those exposed to a steam blast bent double as before.

I was not able to be present about the middle of March when the samples marked *IV* were bent—say, two months old —and instructions seemed to have been misunderstood; for Nos. 6 and 17 were evidently annealed, Nos. 11 and 24 appeared to have been steam-heated, and presumably Nos. 5 and 18 were bent at the ordinary temperature, and not, as intended, after freezing. No. 5 bent double, but cracked on the inner radius; No. 18 bent nearly double, and broke nearly through both inside and out. On account of the above-mentioned uncertainty, it is impossible to say whether deterioration, as compared with Nos. 2, 8, 16, 22 had taken place, or improvement, as against Nos. 4 and 10.

On July 28, 1891, I tested the last four samples, Nos. 12, 13, 23, 26. They were all first placed in the freezing mixture, and on bending all proved quite brittle. No. 26 (bent down) behaved best, bending to an inner radius of about ⅜ inch before cracking. No. 13 (bent down) bent to more than a right angle, with a radius of ¾ inch, and broke short. No. 23 (bent up) bent to a little less than a right angle, with a radius of ¾ inch, and also broke short, and No. 12 (bent up) broke off short after bending through an angle of only 20 degrees. Irregularities in the results are attributable to the difficulty of getting equally cold temperatures.

These results could leave no doubt but that the material did deteriorate at ordinary temperatures, but the effect could

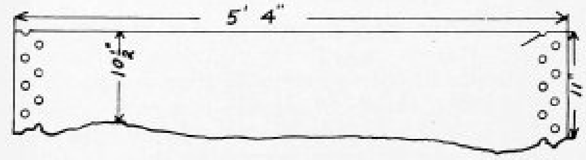


FIG. I.—TEST PIECE CC.

be made apparent only if the samples were made very cold before bending. Recently this ageing effect has been confirmed on the projecting ends of Nos. 2, 8, 16 and 22, which have now been bent—*i. e.*, after sixteen years' waiting—at ordinary temperatures. In each case the samples cracked at both edges when the bending amounted to a right angle, and the inner radius was about ⅜ inch. However, the two annealed samples, Nos. 6 and 17, have bent double, showing that the brittleness has to be started by such severe straining as occurs with shearing. This steel appears to have been made by the acid Bessemer process, and several other boilers made from the same material gave trouble in practice and had to be replaced.

The difficulty of demonstrating the ageing effect, except either by freezing the samples or by waiting several years, even although the material, after passing the surveyor's test, deteriorated so much as to burst at a hydraulic test pressure of

Number	1—2	3—4	5—6	7—8	9—10	11—12	13
Down or up	D—U	D—U	D—U	D—U	D—U	D—U	D
Date	I—I	II—III	IV—IV	I—I	II—III	IV—V	V
Condition	F—C	H—F	..—A	F—C	H—F	..—F	F
Number	14—15	16—17	18—19	20—21	22—23	24—25	26
Down or up	D—U	D—U	D—U	D—U	D—U	D—U	D
Date	I—II	II—IV	IV—III	I—II	II—V	IV—III	V
Condition	H—F	C—A	..—H	H—F	C—F	..—H	F

D = bent down.
U = bent up.
C = bent at ordinary cold temprratures.
H = bent at about 212° F., after exposure to a steam blast.
F = bent after being cooled down to about 10° F. in a freezing mixture of salt and ice.

Fig. 2.—Plate CC. rolled down to ⅝-inch thickness and cut up.

about 25 percent excess over the working pressure, decided me to postpone any further researches until I had collected other samples which had given trouble in practice. These I proposed to compare with steel from recognized first-class steel makers, both British and foreign, and I have gradually collected the plates enumerated in Table I. The date of receipt is stated as there are indications that the older samples have improved.

TABLE I.

O, Chrome vanadium steel, ⅜ inch thick, 1906.

V, North British acid open-hearth, 1906, ordinary quality, ¾ inch thick.

W, North British acid open-hearth, 1906, hard quality, ¾ inch thick.

X, North British basic open-hearth, 1906, dead soft quality, ¾ inch thick.

Y, North British acid open-hearth, 1906, ¾ inch thick.

Z, North British basic open-hearth, 1906, ordinary quality.

BB, English acid open-hearth, 1907, ordinary quality, ¾ inch thick.

S, English acid open-hearth, 11/16 inch thick, intended for butt-straps. It broke, 1905, while test strips were being sheared at boiler works. It contained much phosphorus and strong central segregations.

A, German (*I*) basic open-hearth, 1892, very mild, ⅝ inch thick.

B, German (*I*) basic open-hearth, 1892, medium mild, ⅝ inch thick.

C, German (*I*) basic open-hearth, 1892, 30-ton steel, ⅝ inch thick.

D, German (*I*) basic open-hearth, 1892, medium mild, ⅝ inch thick. Phosphorus and sulphur above usual average.

E, German (*I*) basic open-hearth, 1892, medium mild, ⅝ inch thick. Phosphorus and sulphur above usual average.

F, German (*I*) basic open-hearth, 1892, medium mild, ⅝ inch thick. About 0.25 percent phosphorus and much sulphur.

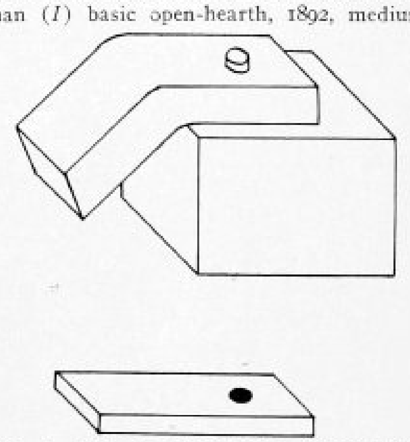


FIG. 3.—METHOD OF MAKING BENDING TEST.

G, German (*I*) acid open-hearth, 1892, ordinary quality, ⅝ inch thick.

H, German (*I*) acid Bessemer, 1892, ordinary quality, ⅝ inch thick.

J, German (*II*) basic open-hearth, 1892, quality not stated, ⅝ inch thick.

K, German (*II*) basic open-hearth, 1892, quality not stated, ⅝ inch thick.

L, German (*II*) basic open-hearth, 1892, quality not stated, ⅝ inch thick.

R, Boiler shell plate, which cracked in 1903 while being bent in boiler maker's roll, before planing edges. Thickness, ⅞ inch. North British acid open-hearth. Accidentally a truck-load of phosphoric pig had been charged into the acid open-hearth furnace. All inspectors' tests and subsequent tests were good. Phosphorus, 0.165 percent.

T, Part of a marine boiler shell plate, 1⅛ inches thick, which burst in London under the hydraulic test about 1890. Details of manufacture were not obtainable. Possibly similar material to *CC*.

M, Butt-strap of a large water suction pipe, of which duplicate burst while at work. Believed to be basic Bessemer steel made in 1892, 7/16 inch thick, 4 inches wide.

N, Shell plate of a boiler, which cracked longitudinally after four years' work, built 1889, failed 1893, ½ inch thick. Adjoining boilers also cracked, and all were discarded at once.

P, Plate from a boiler which exploded at Rochester, United States America, in 1897, said to be due to an incipient crack. The plate as received had no fractured edges; thickness, ⅜ inch.

Q, Plate from a boiler which burst, Oct. 17, 1905, in Austria, while being tested at the maker's works.

U, Boiler shell plate which burst, 1904, under the Russian government inspector's hydraulic test, after being in use for six years. The adjoining boiler burst in the same way in 1905.

The desirability of commencing the tests made itself felt in 1904-1906, when the specimens *U* and *Q* were received, and *R*, *S* and another plate, No. 9, cracked in the boiler works. The difficulty, however, which had hindered inquiry in the past had not been removed, and no test had yet been devised which would reveal that brittleness in plates which seemed to cause them to fail when riveted up, but did not show itself in the ordinary testing. Over and over again tensile and cold and temper-bending tests have given satisfactory results with plates which have failed as structures. It was, therefore, desirable, if possible, to try and find a discriminating test and it was finally decided to carry out as many tests as possible, and to establish a co-relation, if that existed. But as the feeling was already a strong one that shearing stresses could produce an ageing effect, a case similar to *S*, which occurred in 1905, was first dealt with as follows:

Narrow test pieces were sawn out of the plate, the first being close to the sheared edge, and these were tested for elastic limit, tenacity and elongation. The results showed that there is practically no difference between the samples taken from near the edge and those further away from it. Yet there could be no doubt but that the material had been injured by shearing, for not only did the strips which were sheared off in the boiler shop prove to be brittle, but other strips sheared off at the steel works after the plate was returned were also brittle. All these strips had one old and one new sheared edge. Other strips taken from further in the plate, with both edges newly sheared, behaved excellently. Evidently the shearing stress had not yet had time to create brittleness. The other plates from the same charge behaved equally well, although the test strips had old sheared edges. The analysis was also good. The only cause which can be suggested for the brittleness which in the one plate gradually extended from the sheared edges, was that possibly this one cogged slab had remained for two heats in the reheating furnace, but absolutely no confirmation of this view could be obtained.

This experience confirmed previous ones, that tensile tests are not as good as bending tests for detecting brittleness. But bending tests of samples with sheared edges are also not satisfactory, for so very much depends on the condition of the shears. For this reason all the samples of the experiments, *A* to *Z* and *BB*, now to be described, were sheared at one time; but even now one could see that different edges were obtained, according to the manner in which the men held the plates; and although the shearing blades were new when starting, they soon got roughened and chipped, so that one cannot feel sure that the shearing effect is the same either in all samples or in different lengths of the same sample. Bending tests with sheared edges were, however, decided on, as well as alternate bends of samples having sheared edges. This method was first adopted in my investigation on the "Working of Steel and Iron at a Blue Heat."[2] The test has been considerably improved on this occasion. Each test piece has now had a hole punched into one of its ends (see Fig. 3), and this is fitted over a projecting stud of the anvil block, whose one face has a slant of 45 degrees. By this means one can ensure that the bending would always take place at one point.

Neither of these tests, nor the tensile test, can be considered as being capable of revealing local brittleness, for before the sample ruptures it will have been subjected to enormous

[2] Minutes of proceedings of the Institution of Civil Engineers, 1885, vol. lxxx., iv., page 114.

deformations. Thus in tensile test pieces a not unusual contraction of area of 50 percent is of necessity associated with a local elongation of 100 percent, and any local hardness would, most probably, be kneaded into a thorough plastic condition before it could do harm. The same results apply to the ordinary bending test. The idea, therefore, suggested itself to localize the injury, and also to locally weaken the section, so as to start a local fracture if brittleness had been created. With this end in view, the uncertain effect of shearing set up was, in one batch of samples, entirely removed by annealing, and the samples were then nicked across their widths by a chisel, shaped as shown in Fig. 4, which projected out of the flat, and could penetrate the metal only to a certain depth. The samples were then bent, the nick being on the outer curvature. This proved to be too severe a test, more especially after the brittleness due to the nicking pressure had had time to spread. Other batches had been annealed and the sides planed flat, and were then nicked on the edge and bent. This test was found to be of a fairly discriminating nature, some samples bending double, while others bent through only a few degrees. Four tests were made on samples cut from one strip, with the following inner radii: 9/32 inch, 5/16 inch, 7/32 inch and 7/32 inch. The results obtained by this test, as recorded in Table 2, are also so very consistent that I feel sure it will recommend itself, if not for general use, at least for special investigations.

Samples Annealed, Planed on Edges and Nicked on Edges (see Table 2).—There are two sets of these tests. The first set, Nos. 2 and 14, were respectively bent immediately after nicking and twelve weeks later. Nos. 11 and 23 were respectively bent immediately after nicking and after boiling at 212 degrees F. and waiting one day. This second test was carried out at the suggestion of Dr. Ewing. His opinion, which has been thoroughly confirmed by these tests, being that any hardening process which might be going on would be very materially accelerated by this short boiling. This second lot of samples was not annealed, planed and nicked until twelve

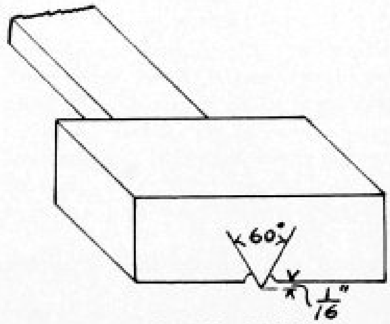


FIG. 4.—NICKING CHISEL.

weeks after the first lot, and, unfortunately, the annealing conditions were not quite the same for the two lots. This will account for discrepancies as regards the lots Nos. 2 and 11, which ought, in all cases, to be in close agreement; but it is only *A*, which material has all along behaved rather erratically, that there is any serious difference.

Exceptionally good first tests were obtained with samples *A*, *L* and *P*. Next in order come *P*, *E*, *G*, *J*, *S*, *T*, *U*. The worst results are *C*, *F*, *R*, *Y*. This might have been expected for these steels; but only one of the eight steels which misbehaved themselves is amongst the last four, so that it is evident that the single nicking test does not reveal all bad qualities.

As regards the ageing effect, it will be noticed, if the twelve

No.	2.†				14.					11.				23.†				
Age When Bent.	0.				12 Weeks.				Ageing Effect.	0.				Boiled and Bent next day.				Effect of Boiling.
Plate.	Bent.‡	Inner Radius. Inch.	Outside Stretch. Percent.	Fracture.*	Bent.‡	Inner Radius. Inch.	Outside Stretch. Percent.	Fracture.*	Nos. 14. / Nos. 2.	Bent.‡	Inner Radius. Inch.	Outside Stretch. Percent.	Fracture.*	Bent ‡	Inner Radius. Inch.	Outside Stretch. Percent	Fracture.*	Nos. 23. / Nos. 11.
O	u	9/32	38	S.	d	Broke	0	C.	0	d	11/32	34	S.	d	Broke	0	C.	0
V	u	9/32	43	S.	u	3/8	36	S.	0.83	d	1/2	27	S.	d	7/16	31	S.	1.14
W	u	7/32	49	S.	u	3/4	16	S.	0.33	d	1/2	27	S.	d	3/4	16	S.	0.59
X	u	11/32	38	S.	u	3/16	51	S.	1.34	d	1/2	27	S.	d	9/32	43	S.	1.59
Y	u	1/2	27	S.	u	3/4	16	S.	0.59	d	1/2	27	S.	d	3/4	16	S.	0.59
Z	u	7/16	31	S.	u	1/2	27	S.	0.87	d	9/32	43	S.	d	7/32	49	S.	1.14
BB	u	11/32	38	S.	u	3/4	16	S.	0.42	d	3/8	36	S.	d	11/32	38	S.	1.10
S	u	7/32	49	S.	d	3/16	51	S.	1.04	d	9/32	43	S.	d	3/4	16	C.	0.37
A	u	Close	68	S.	u	3/16	51	S.	0.75	u	7/16	31	C.	d	3/4	16	C.	0.52
B	u	3/16	51	S.	u	3/4	16	S.	0.31	u	5/16	51	S. br.	u	1/2	27	C.S.	0.53
C	u	7/8	12	C.S.	u	3/4	16	C.S.	1.33	u	1.2	6	C.	u	3/4	16	C.S.	2.66
D	u	1/2	27	C.S.§	u	5/16	51	C.S.	1.84	u	3/8	36	S.	u	9/32	43	S.	1.19
E	u	5/32	53	S.	d	7/32	49	S.	0.91	u	. 9/32	43	S.	u	3/4	16	C.	0.37
F	u	7/8	12	C.	u	3/4	16	C.	1.33	u	3/4	16	C.S.	u	1/2	27	C.	1.67
G	u	9/32	43	S.	u	7/16	31	S.	0.72	u	9/32	43	S.	u	3/8	36	S.	0.83
H	u	7/32	49	C.S.	u	3/4	16	C.S.	0.33	u	7/16	31	C.S.	u	7/8	12	C.S.	0.89
J	d	7/32	49	S.	d	3/4	16	C.	0.33	u	7/32	49	S.	u	7/16	31	C.S.	0.63
K	u	3/8	36	C.S.	d	11/32	38	S.	1.05	u	1/2	27	S.	u	3/4	16	C.S	0.59
L	u	Close	68	S.	u	5/32	53	S.	0.78	d	11/32	38	S.	u	3/4	16	C.	0.42
R	u	1	10	C.	u	3/4	16	S.	1.60	d	1/2	27	S.	d	9/32	43	S.	1.59
T	u	5/32	53	S.	u	11/32	38	S.	0.71	d	3/8	36	S.	d	3/4	16	S.	0.44
M	d	Close	68	S. §														
N	u	3/8	36	C.	u	7/16	31	C.S.	0.86	d	1/2	27	S.	d	1/2	27	S.	1.00
P	d	Close†	68	S.	u	1/8	55	S.	0.81	d	Close	68	S.	d	1/8	55†	S.	0.67
Q	d	3/16	51	C.S.	d	1/2	27	C.	0.53	u								
U	d	5/32	53	S.	d	9/32	43	C.S.	0.81	d	11/32	38	S.	u	3/4	16	C.	0.42

* S. = Silky fracture. C. = Crystaline fracture. C.S. = Crystaline fracture near nick, silky beyond, especially on outer edge.
† P_{30} substituted for P_{14}.
‡ Bent up or down; *u*, *d*.
§ These samples may have got hardened while lying on the mill floor.

TABLE 2.—Samples Annealed, Planed on Edge, Nicked on Edge, and Bent.

weeks' waiting tests and those after 15 minutes' boiling be compared, that the results with samples *A, G, H. O, P, R, X, Y* are in close agreement. Of these both *R* and *X* have improved with age. *A, G. P* have deteriorated somewhat, and *H* and *Y* very considerably.

Rather less consistent results were obtained with the samples *B, F, J, L, N, T, U, V, W, Z*. Of these *F* only has improved; *V* and *Z* may be classed as not having changed; *L, T, U* have deteriorated somewhat, and *B, J, W* rather much. The discrepancies with regard to the remaining six samples are rather large; but even in cases *K* and *S* and *BB*, where the effect produced by ageing is the reverse of that produced by boiling, one may safely say that there is either no effect or a deterioration. *C* and *D* have materially improved, and *E* has distinctly deteriorated.

These deductions and remarks about the plates are contained in Table 3.

TABLE 3.—AGEING EEFFECTS ON SAMPLES WHOSE PLANED EDGES WERE NICKED. NOS. 2, 11, 14 AND 23. SEE TABLE 2.

C, Improved. German basic 30-ton steel.
D, Improved. German basic steel. High phosphorus.
F, Improved. German basic steel. Very high phosphorus.
R, Improved. North British acid steel. High phosphorus.
X, Improved. North British basic steel. Dead soft.
V, No change. North British acid steel. Ordinary quality.
Z, No change. North British acid steel. Ordinary quality.
A, Deteriorated. German basic steel. Very mild.
E, Deteriorated. German basic steel. Medium.
G, Deteriorated. German acid steel. Ordinary quality.
K, Deteriorated. German basic steel.
L, Deteriorated. German basic steel.
N, Deteriorated. British steel. Boiler shell cracked; four years old.
P, Deteriorated. Plate from an exploded boiler. Rochester, U. S. A.
Q. Deteriorated. Plate from a dome which burst during test. Austria.
S, Deteriorated. English acid steel. Broke in shears.
T, Deteriorated. Marine boiler shell. Burst during test.
U, Russian boiler. Burst when six years old.
BB, Deteriorated. English acid steel. Ordinary quality.
B, Much worse. German basic steel. Medium quality.
H, Much worse. German acid Bessemer steel.
J, Much worse. German basic steel.
W, Much worse. North British acid steel. Hard quality.
Y, Much worse. North British acid steel.
O, Grew brittle. Chrome vanadium basic steel.

These results are fairly encouraging, in so far as that all those samples which were rolled from plates that had misbehaved themselves are among those in which the ageing effect is one of deterioration. The only exception is *R*, which is a plate which broke while being sheared; but it will be noticed that it is in close company with two other steels in which, as in this case, the phosphorus is high. The ageing effect in these samples seems to have been to improve them. In practice one would hardly expect this result, so that although the nicking test does seem to single out certain defective qualities of steel, it should not be relied upon to detect phosphoric steels, and should not be used until a more extended experience has been gained with it at steel works and in boiler shops.

The conclusions to be drawn from these several tests are that certain steels do possess ageing qualities, that some steels tend to improve with time, others to deteriorate. That as yet the process which gives results which are most in harmony with practical experience is to plane the edges of two samples, to nick them with a specially prepared chisel, and then to bend one sample at once and the other after waiting some weeks or after boiling.

I hope, before I complete these experiments that I may receive suggestions as to what I should do with a few odd batches of samples; but when the work is ended I at least would be the last to suggest that 800 tests, no matter how systematically they may have been carried out, should in any sense outweigh the practical experience which engineers have gained with millions of different forms and sizes of structures. Although I am responsible for the safety of over 8,000 boilers, I do not feel alarmed by the knowledge I have gained that steel and iron have ageing tendencies; for cases are brought to my notice every year in which structures have been loaded far beyond the customary limits and yet have shown no signs of giving way. These are experiences which it is difficult to explain, except on the supposition that some materials improve with age; but they naturally raise the question as to whether one cannot perceive that all materials should be of this nature, in which case many customary high factors of safety might be considerably reduced. The value, in my opinion, of the results obtained in these experiments is that they direct attention to a subject which, if followed up, may lead to an improvement of the ageing properties of steel.

Short Method of Laying Out Elbows and Bends to any Degree.

BY CHARLES E. FRICK, GENERAL FOREMAN, NEW JERSEY BOILER COMPANY, BOONTON, N. J.

It is generally the case that a layerout has his own rules for laying out different lines of work, and becomes so much adapted to them that he will very seldom change his method for one which might be a little quicker. The reason for this is that he will probably have to experiment with the new method, while he knows that the old method has been doing the work satisfactorily all along. Herewith is illustrated and described, however, a short method to be used in getting out the patterns

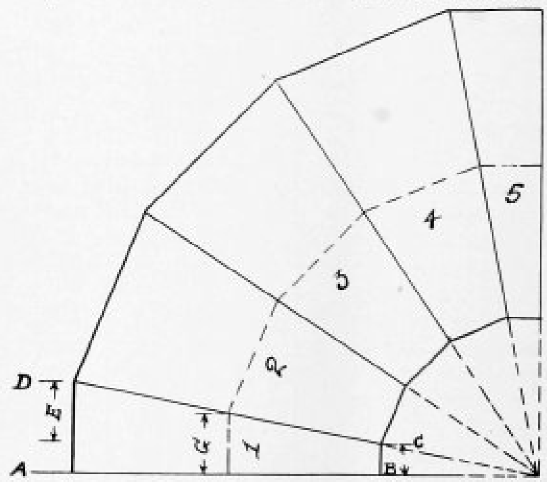


FIG. 1.

for elbows and bends. This method has been used by the writer for a number of years, and has been found to be very handy and accurate, and also to save considerable time in laying out the different patterns.

Consider, for example, the elbow shown in Fig. 1, draw a side view of it, which, if very large, may be reduced to a scale of 1½ or 3 inches to a foot. The elbow is to be made in five taper courses, and it will be noted that the end pieces will be one-half the width of the center pieces. All that is needed from the elevation, Fig. 1, is the difference in height of *AD* and *BC*, as shown at *E*, and also the height at *G*. This will be apparent from the layout of Figs. 2 and 3. First layout one of the middle pieces, the seam of which is to be one-quarter of the way around from the throat of the bend. Draw the horizontal lines, *AB* and *CD*, Fig. 2, and make *AC* and *BD* equal to twice the height *G*, Fig. 1. Make *AB*, Fig. 2, equal to the circumference of the small end; then get the camber in the piece and draw the curve for a taper ring. With a radius equal to one-half the distance *E*, Fig. 1, draw a quarter circle on any part of the plate, as shown at 1*H*5, Fig. 2. Divide this arc into one-quarter as many parts as there will be in the pattern. In this elevation shown in Fig. 1, in order to use the above method.

Figs. 4 and 5 show a short method of laying out domes or small cylinders, which intersect a larger cylinder, as shown in Fig. 5. The only thing required here is the allowance needed, as shown at *H*, Fig. 5, then take up the plate required to make the shell, Fig. 4, and lay down the height required above the cylinder, shown at *F*, Fig. 4. Draw a semi-circle equal to the allowance *H*, Fig. 5, and divide it into any number of equal parts. In this case four equal parts have been used. Draw

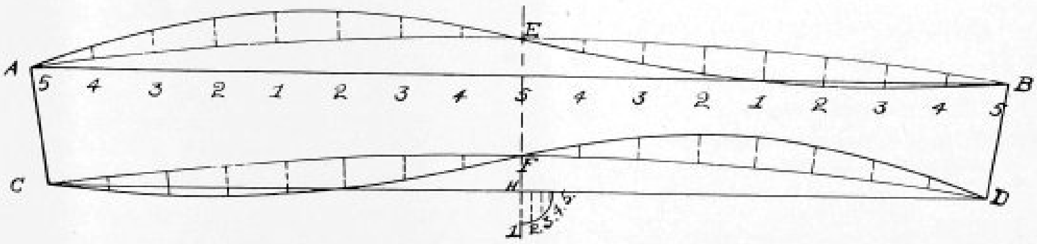


FIG. 2.

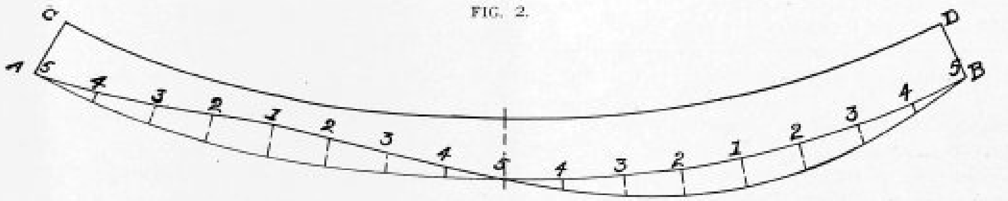


FIG. 3.

case, since there will be sixteen parts in the pattern, there will be four divisions in the arc, as indicated. Draw vertical lines from these points intersecting the horizontal line *H*5. Having drawn and marked the lines in the taper sheet, take the different heights indicated by the vertical lines on the quarter circle as *H*1, etc., then add these distances on, as shown by the corresponding numbers from *A* to *E* and *C* to *F*; also take them off, as shown by coresponding numbers from *E* to *B* and *F* to *D*; then draw lines intersecting these points, and you will have the lines for the pattern at the center of the rivet holes; add the necessary lap and step off the holes on the curved line, and the pattern required for the three center pieces will be complete.

In laying out the end pieces, proceed as in Fig. 2, except that the distances *AC*, Fig. 3, will equal the height at *G*, Fig. 1, instead of being twice the height as in Fig. 2.

It is necessary that the camber line be drawn on the plate for taper courses, and the dimensions for the miter curve be added, and taken off from the camber line, in order to make the curve which locates the intersection at the miter joint accurate.

In making the allowance for take-up in rolling, the writer finds it practical to allow three and one-half times the thickness of the plate for outside courses, and to take off three and and one-half times the thickness of the material for inside courses, which makes seven times the thickness difference between an outside and an inside course. In some shops the draftsman gives the height of the different cambers on the drawings. When this is done it is unnecessary to draw the

horizontal lines intersecting the points on the semi-circle, then divide the plate into four equal parts and draw lines, as shown in *ABCDE*, Fig. 4; then with the dividers, or a rule, divide each of the four parts into as many spaces as there are in the semi-circle *H*; draw lines intersecting these points, and the required curve will be obtained. Note that the four parts from *A* to *B*, etc., are divided on an incline, as from *A* down to *B*, and *B* up to *C*, etc., each of the four points intersecting a corresponding line from the semi-circle.

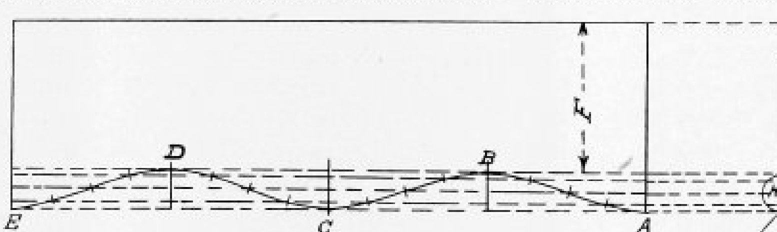


FIG. 4.

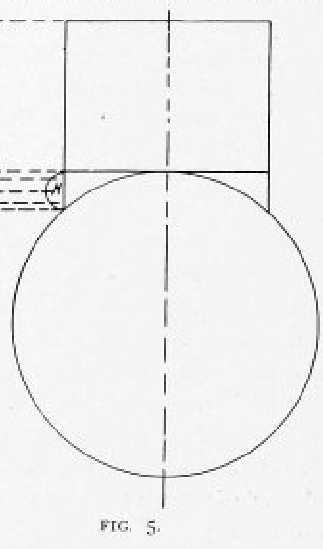


FIG. 5.

A cement that was commonly used on the Fallbrook Railroad locomotive front-ends some years ago to stop cracks and leaks, was composed of litharge mixed with sufficient boiled linseed oil to make a stiff paste. Into this paste was thoroughly mixed about one-third bulk of old rope cut into short lengths—about 1 inch—and separated into its constituent fibers. This cement hardens like iron and the rope fibers hold it together while drying and also prevent squeezing out when the front-end casting is bolted to the smoke-box.

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - - New York

Christopher St., Finsbury Square, London, E. C.

H. L. ALDRICH, President and Treasurer

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Branch Offices.

Philadelphia, Pa., Mach'y Dept., The Bourse, S. W. ANNESS.
Boston, Mass., 170 Summer St., S. I. CARPENTER.
Chicago, Ill., 625 Monadnock Building, H. S. MOSS.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico	$1.00	.10
Other countries in Postal Union	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

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.

The Perry Theory.

The theory of boiler efficiency which was presented a few years ago by Mr. John Perry, showed the possibility of greatly increasing the efficiency of existing types of boilers. This theory, however, did not lead to any marked change in the design or construction of boilers or furnaces at that time, as the theory was not borne out by sufficient tests to give conclusive proof of its value. Recently, however, the fuel testing department of the United States Geological Survey has carried out a series of experiments which corroborate and extend this theory (see article "Increasing the Efficiency of Steam Boilers," page 241), and as a result of its work makes the startling statement that the stationary boilers in use to-day should be made to do from ten to twenty times as much work per unit area of heating surface as they do now. This great increase is to be accomplished by forcing the hot gases through the boiler at a very much greater velocity than is now the case, as it has been found that the faster the gases travel parallel to the heating surface the greater the amount of heat which is transmitted from them to the water in the boiler, due to the scrubbing off of the colder gases which lie next the surface. If the boilers of the future are to evaporate from 30 to 60 pounds of water per square foot of heating surface per hour instead of three, as the report would seem to indicate they might do, it will be seen at once that some marked innovations must be made to provide for the circulation of the water in the boiler and also for the rapid combustion of a large amount of fuel. These are matters, however, in which there has been little enough progress in the past and any advance will be eagerly welcomed. The reliability of the source from which this information comes is such that the importance of the work can hardly be estimated and the later reports of the department will be awaited with much interest. One important result of the acceptance of this theory would be that the steam boiler could be rated on a more secure mathematical basis than is now the case.

Massachusetts' New Boiler Inspection Law.

As a result of several particularly disastrous boiler explosions which have occurred recently in Massachusetts a large number of bills were presented at the last session of the State Legislature, the main object of nearly all of them being to provide for a more thorough and efficient system of boiler inspection and incidentally to prevent such dangerous features of construction, as the lapped longitudinal seam has proved to be, from being used in the State. The committee to which all of these bills were referred submitted to the legislature a new bill which was enacted into a law that will go into effect October 1, 1907. This new boiler inspection law is drawn on very progressive lines, giving the State Boiler Inspection Department jurisdiction over all the boilers in the Commonwealth. Provision is made for the appointment by the Governor of a State Board of Boiler Rules composed of members representing the boiler manufacturers' interests, the boiler users' interests, the boiler inspection companies' interests, the boiler inspectors' interests and the operating engineers' interests. The law provides that it shall be the duty of the Board of Boiler Rules to formulate rules for the construction, installation and inspection of steam boilers, and for ascertaining a safe working pressure to be carried on such boilers, to prescrcibe tests, if it deems necessary, to ascertain the quality of materials used in the construction of boilers, to formulate rules regulating the construction and sizes of safety valves for boilers of different sizes and pressures, the construction and location of fusible safety plugs, appliances for indicating the pressure of steam and level of water in the boiler, and such other appliances as the Board may deem necessary for safety in operating steam boilers, and also to make a standard form of certificate of inspection.

The first Board of Rules to be appointed under this law was confirmed by the Governor on July 5, the term of office of its members varying from two to three years. The work of these men will be watched with interest by boiler makers in other States; for if the Board succeeds in bettering the conditions affecting safe boiler construction and inspection in the State of Massachusetts without undue antagonism from any of the many interests represented in the Board, there may be some hope of accomplishing the same result elsewhere with a possibility that in time we may have a Federal Board which shall bring about uniform protection for steam users throughout the country.

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.—In flue work, how much, if any, should a copper ferrule project through the flue sheet, and how much should be allowed for beading the flue? A. B. C.

A.—Set the copper ferrule flush with the flue sheet on the fire-box side and allow 3-16 or a scant ¼ inch for beading the flue.

Q.—What are the usual values for the area of the grate surface, the heating surface, steam and water space, rate of evaporation, combustion tube area and area of up-take and chimney for a 72-inch boiler, 18 feet long, carrying 150 pounds steam pressure and rated at 150 hp. HORSEPOWER.

A.—Since the number and size of tubes is not stated the exact area of the heating surface cannot be obtained. However, if the boiler is rated at 150 hp. it means that there will be a total equivalent evaporation of $150 \times 34.5 = 5,175$ pounds of water per hour.

Assuming an equivalent evaporation of 9 pounds of water per pound of coal, the number of pounds of coal burned per hour would be $\frac{5,175}{9} = 597$ pounds.

Again, assuming that 12 pounds of coal are burned per square foot of grate area, the grate area would be $\frac{579}{12} =$ 48.3, or 49 square feet. The average ratio of heating surface to grate area in a boiler of this kind is about 35. Therefore, with a grate area of 49 square feet, the boiler should have a heating surface of 49 x 35, or about 1,700 square feet.

Assuming that the boiler has 86 tubes 3½ inches in diameter (which would be fairly good practice for a boiler of this size), the heating surface would figure out about 1,689 square feet. Therefore, the result obtained by assuming the number of pounds of water evaporated per pound of coal and the number of pounds of coal burned per square foot of grate area, which assumptions are, of course, based upon results obtained in actual practice, is very nearly the same.

The ratio of steam to water space would depend somewhat upon the service for which the boiler is used. The steam space is usually figured according to the amount of steam consumed by the engine, and will, therefore, vary a good deal according to the type of engine. As this is not known in the problem under consideration, 1 cubic foot of steam space may be allowed for each horsepower, making 150 cubic feet of steam space. Another rule sometimes used is to make the steam space equal to one-third the volume of the boiler. In either case the steam space should probably be between 135 and 150 cubic feet.

The area of the up-takes is usually made about one-seventh of the grate area, and the area of the chimney about one-eighth of the grate area. If the area of the chimney is made a little over 6 square feet and the area of the up-takes about 7 square feet, the proper proportion would be given. The total area of the tubes should not be less than the area of the up-takes, neither should it be very much greater, since if it is greater the gases will seek out the path which gives the least resistance, and only a part of the tubes would be doing any work.

The actual number of pounds of water evaporated by the boiler may be found as follows:

One boiler-horsepower is equivalent to the evaporation of 34.5 pounds of water from and at 212 degrees F. Since the boiler is to be 150 hp., the equivalent evaporation from and at 212 degrees F. would be 5,175 pounds per hour. The heat necessary to evaporate 1 pound of water at 212 degrees F. is found from steam tables to be 965.8 B. T. U. The heat necessary to evaporate 1 pound of water at the boiler pressure of 150 pounds per square inch is equal approximately to 1,166 B. T. U. The heat necessary to evaporate 1 pound of water at boiler pressure times the actual number of pounds evaporated per hour is equal to the heat necessary to evaporate 1 pound of water at 212 degrees F. times the equivalent evaporation. Or, $1,166 \times$ the number of pounds evaporated per hour $= 965.8 \times 5,175$.

The actual number of pounds evaporated per hour = 4,285 pounds.

$\frac{4,285}{1,689} = 2.54$ pounds of water evaporated per square foot of heating surface per hour.

Q.—What are some of the advantages of radial stayed crown sheets? LOCOMOTIVE.

A.—With a radial stayed crown sheet the stays may be placed as nearly as possible at right angles to the plates, thus making a very strong form of construction. The crown of the sheet permits the mud or sediment, which is deposited from the water, to be washed off the crown by the movement of the water in the boiler, and thus keeps the sheet from overheating in case of low water.

A flat crown sheet must be stayed with crown bars, which not only take up considerable water space but serve to keep any sediment which is deposited from the water on top of the crown sheet and also to make washing inconvenient.

Q.—Will an explosion necessarily result from injecting water into a red-hot boiler? FIREMAN.

A.—Some very practical tests have been made to determine the effect of injecting water into a boiler in which the water has become low and the sheets overheated. Several years ago the Manchester Steam Users' Association made three tests, where in each case the boiler plates were heated nearly to redness; water was then introduced with the result that in one case the steam pressure was raised within a minute from 6 to 27 pounds, but in the other cases the pressure was not increased any appreciable amount. The effect of the sudden change of temperature was to distort the plates and tubes, but not in such a way that an explosion was at all likely to result. Another instance which we have in mind is a case where a locomotive was taken out on a spur where an explosion could do no damage and then fired up. After the boiler was well heated the water was blown out, and when the crown sheet began to reach a red heat cold water was quickly pumped into the boiler, the only result being that the steam went down. This experiment was repeated several times, and, while the boiler was injured by the fire it did not explode. In another instance a cast iron boiler was fired up to a pressure of about 170 pounds, when the blow-off cock was opened and all of the steam discharged. After waiting 10 minutes and heating the furnace so that a stick of wood placed against the boiler would immediately become ignited, water was injected into the boiler. In this case no steam was raised, the only effect being to cool off the boiler. These experiments seem to show that the whole mass of a boiler if heated red hot does not contain heat enough to raise the water in the boiler up to the steam point, and that there is very little likelihood that an explosion would result solely from the effect of pumping cold water into an over-heated boiler.

Q.—How can the development of the transition piece shown in Fig. 1 be obtained? J. R. S.

A.—It will be necessary to use the method of triangulation to solve this problem, and since the transition piece is symmetrical a quarter pattern will suffice.

First divide the upper and lower edges of the transition piece into any number of equal parts. The equal spaces on the upper edge may be stepped off at once in the plan, as 1, 2, 3 and 4. Since the lower edge does not lie in a plane surface it will be necessary to draw a view of it when laid out flat in order to divide it into equal spaces. This view is shown at the line 1-5, equal in length to the line 1-5, Fig. 1, and with 1 as a center and the dividers set to the distance 1-2 in plan, Fig. 1, draw an arc at the point 2, and with 5 as a center and the trams set to the distance *X*5 draw an arc intersecting the arc previously drawn at 2. With 2 as a center and with the trams set to the solid line *X*6, Fig. 1, draw an arc at the point 6. With 5 as a center and with the dividers set to the distance of the equal spaces *NO*, *Op* and *PS*, Fig. 1, draw an arc intersecting the one previously drawn at 6. Continue in a similar

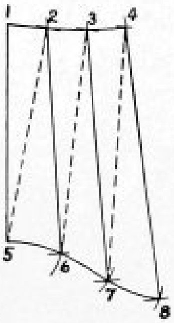


FIG. 2.

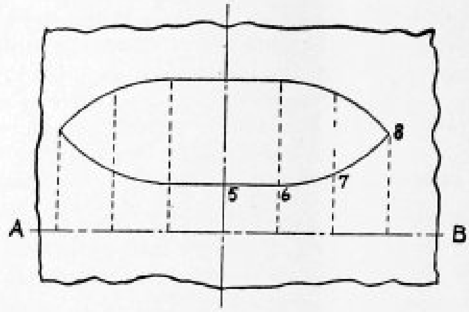
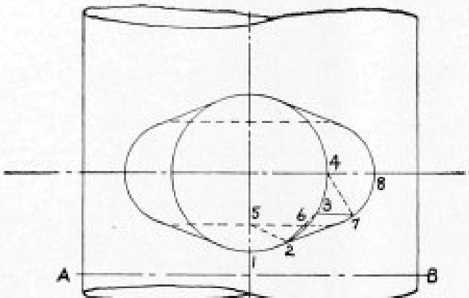


FIG. 3.



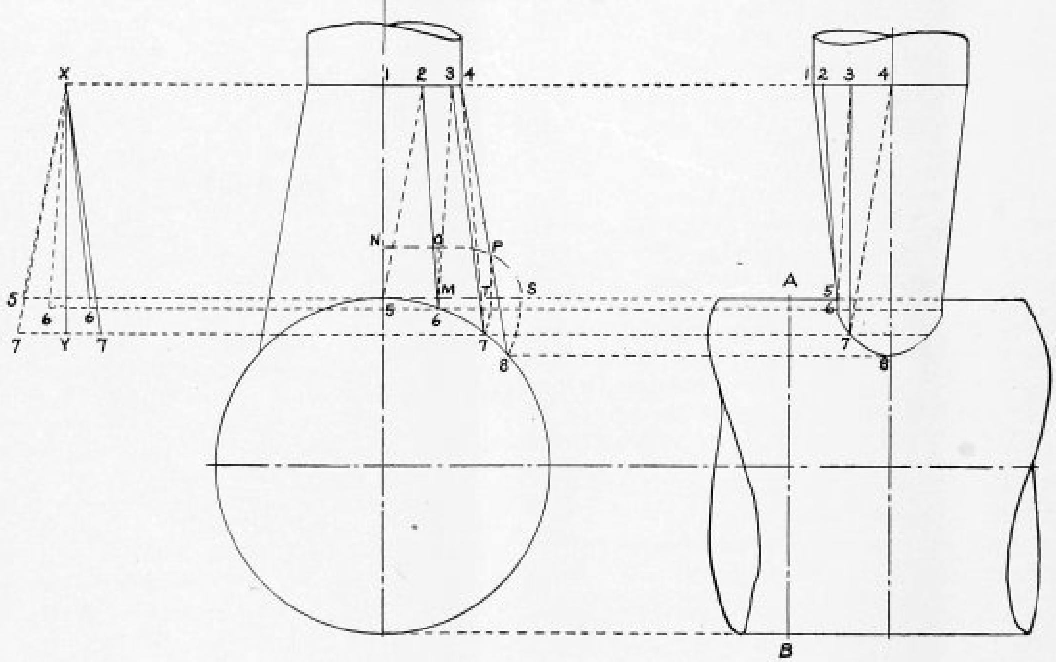


FIG. 1.—PLAN AND ELEVATION OF AN IRREGULAR TRANSITION PIECE.

N, *O*, *P*, *S*, 5 in the side elevation. The distance 5*S* is made equal to the length of the arc 5-8; the distance 5*N* is made equal to half the width of the plan; then take a sufficient number of points on the arc 5-8, and obtaining the off-sets for these points from the plan, construct the remainder of the curve *N*, *O*, *P*, *S*. Divide the curve into three equal parts at points *O* and *P*; project these points to *M* and *T*, and then lay off the distance 5*M* along the arc, locating the point 6, and the distance 5*T*, locating the point 7. Project the points 6 and 7 to the plan view.

Draw the lines 5-2, 2-6, 6-3, 3-7 and 7-4 in both plan and elevation, dividing the surface into triangles. To obtain the true length of these lines project the height of each, as shown in the side elevation to the left and lay off the base of the triangles, measuring the distances from the plan, giving the lines *X*5, *X*6 and *X*7, which are the true lengths of the lines forming the triangles.

The pattern may now be laid out as shown in Fig. 2. Draw manner, locating the points 3, 7, 4 and 8, which will complete the outline of the pattern exclusive of the laps or any allowances which must be made due to the thickness of the material. The development of the opening in the large cylinder may be obtained from the side elevation, Fig. 1, by laying off from a second *AB*, on lines drawn through the points 5, 6, 7 and 8, the distances to the intersection of the transition piece and the large cylinder. This development is shown in Fig. 3.

Q.—Is it necessary in all classes of riveting to make the rivet hole 1/16 inch larger than the rivet? Upsetter.

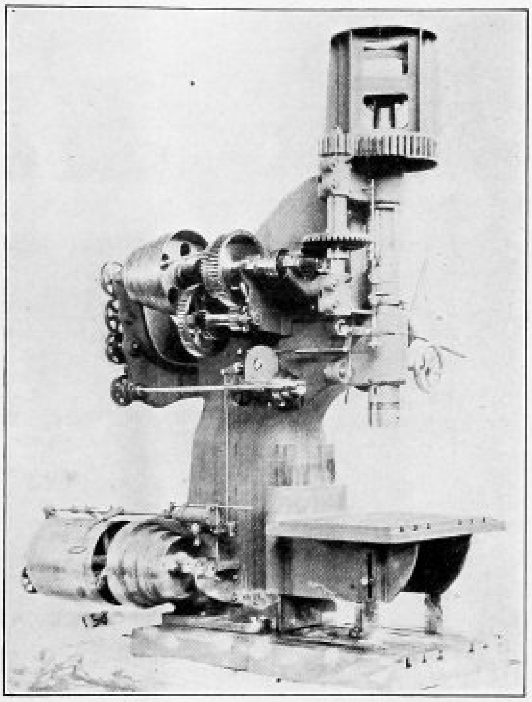
A.—It is the usual practice to make the rivet hole 1/16 inch larger than the rivet, but for absolutely tight riveting where the rivet cannot be driven with sufficient pressure to insure that it will be thoroughly upset its entire length a smaller allowance might be made, say, 1/32 inch. In that case, however, the holes should be perfectly fair and all scale knocked from the rivet.

ENGINEERING SPECIALTIES.

The Baker Sixteen-inch Tapping Machine.

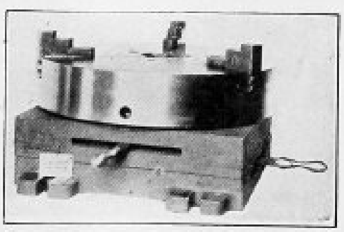
A machine which is well adapted for tapping the usual range of steel boiler flanges is the 16-inch tapping machine manufactured by Baker Bros. Foundry & Machine Works, Toledo, Ohio.

Steel flanges up to 7 or 8 inches in diameter can be handled on this machine as well as light work. The frame of the machine is substantially built in box style, giving great rigidity and freedom from springing. Steel gears are used throughout, and they are unusually heavy, great care being taken to secure



THE BAKER 16-INCH TAPPING MACHINE.

their smooth and efficient operation. A positive geared feed is provided to correspond to the feed of the tap, and it is so applied as to permit the use of collapsing taps. The reversal of the tap is accomplished by means of a special air shifter, operating on open and grooved bolts, in order to eliminate all



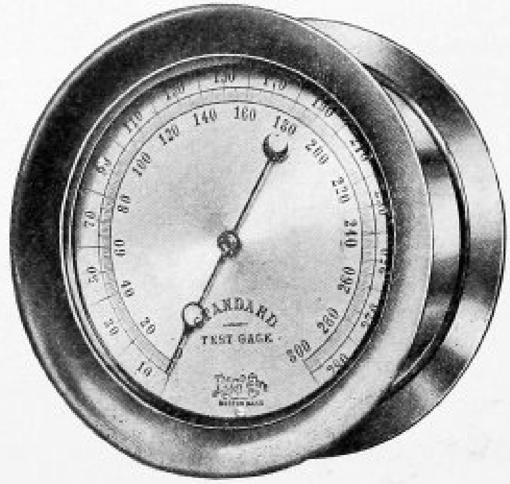
CHUCK USED WITH BAKER TAPPING MACHINE.

clutches or similar contrivances, which are liable to give trouble under extremely heavy loads. In addition to the geared feed there is a hand-worm feed and an automatic depth trip.

The table, which is of the bracket type, has a vertical adjustment by means of a screw of 20 inches. The machine can be furnished either with motor or belt drive and occupies a floor space of only 10 by 4½ feet.

The Ashton Standard Test Gage.

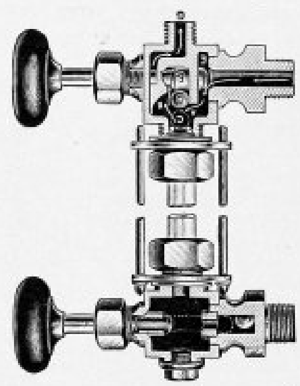
The principal claims made for the Ashton standard test gage, which is manufactured by the Ashton Valve Company, 271 Franklin street, Boston, Mass., are accuracy, sensitiveness and durability. It is made with solid drawn brass steel tubes, the movement being of solid construction and non-corrosive, having German silver pinions and arbors. The springs are well seasoned to prevent setting. Each gage is marked up separately and accurately to exactly match the mechanism of the gage on which it is to be used. The gages are all scaled in 1-pound divisions and may be graduated to any desired maximum up to 500 pounds.



THE ASHTON STANDARD TEST GAGE.

The "Success" Vacuum Automatic Water Gage.

Three important features of the "Success" vacuum automatic water gage which is manufactured by the Penberthy Injector Company, Detroit, Mich., are that the automatic device will not stick or become corrugated; that the automatic balls are forced to their seats when the glass breaks, and that

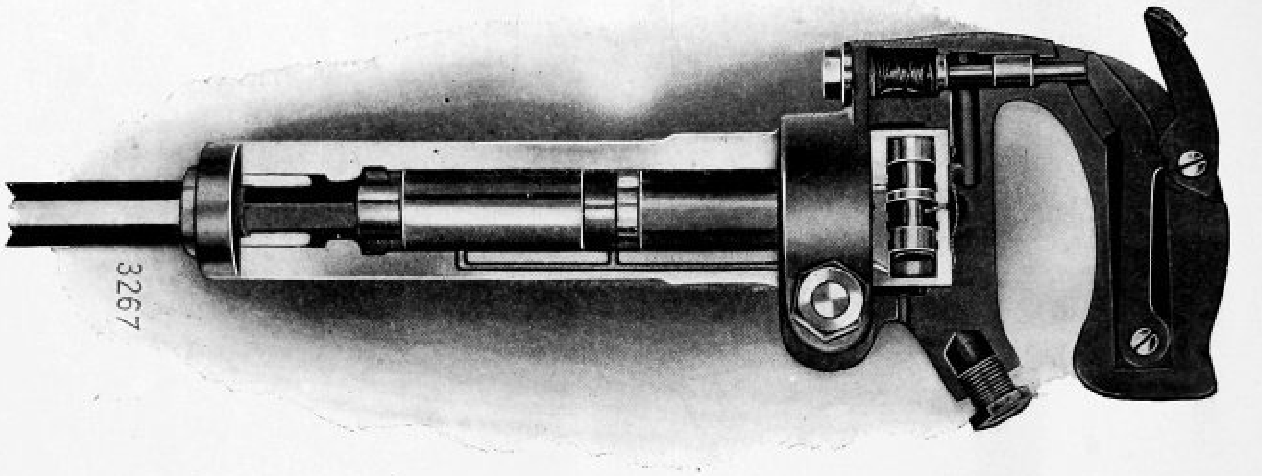


DETAILS OF THE "SUCCESS" WATER GAGE.

the blow-off is operated by a gage handle, giving an opportunity for regrinding the valve seats. This gage was manufactured to overcome the common objections to automatic gages, namely, that the automatic devices are liable to become corrugated and, therefore, not operate at the critical moment, or that they will be forced to their seats on the sudden opening or closing of the blow-off valve. The gage operates as follows: *E* is a double-seated valve to close both the gage and the blow-off so that every time the lower handle is turned to blow off the gage the automatic device, or ball *D*, also is moved by the stem on which it rests. In addition to this the steam follows the course of the arrow *B* to the outlet *G*, creating a downward pressure on the ball *D* and rolling it about in the chamber in which it is located. This movement of the ball, which necessarily occurs several times a day, prevents any tendency to stick. When the glass breaks the operation is reversed, the steam rushing upward toward the break, thus creating a strong vacuum at the lower end of the glass when the ball *D* is instantly raised to the location marked *C*, effectually stopping the flow of steam. The upper ball is forced to its seat by pressure from the boiler.

Crown Pneumatic Hammers.

The Ingersoll-Rand Company, 11 Broadway, New York, have on the market a pneumatic hammer in which the valve diameter. Where the diameter is reduced to provide air passages, strength is maintained by leaving wide fillets. The valve is very light, and therefore produces little vibration when in operation. The valve operates in a valve box, which consists of a solid piece of hardened and ground steel, bored transversely with a hole of uniform diameter. The air ports are simply drilled holes of sufficient diameter and of the least possible length. This construction makes it impossible for the valve box to become loose or get out of adjustment, and also makes it impossible for a careless workman to tamper with the valve. A pressure lower than the full working pressure is always maintained on one end of the valve, while on the other end the full working pressure is intermittently applied. This is



SECTIONAL VIEW OF THE CROWN PNEUMATIC HAMMER.

is operated by unbalanced pressures on a valve of uniform diameter. This is a distinctive feature with this hammer, and it is claimed that the valve can be much more accurately constructed than is the case where a valve must be constructed with two different diameters.

The valve is a plain spool shape, turned from a high grade of steel carefully hardened and accurately ground to a uniform the distinctive feature which has been worked out in the Crown hammer.

The piston and the cylinder are both hardened and ground and are constructed with a view to giving the greatest durability and strength.

A unique feature of the hammer is the use of a screen of unusually large diameter circular in shape, which is inserted

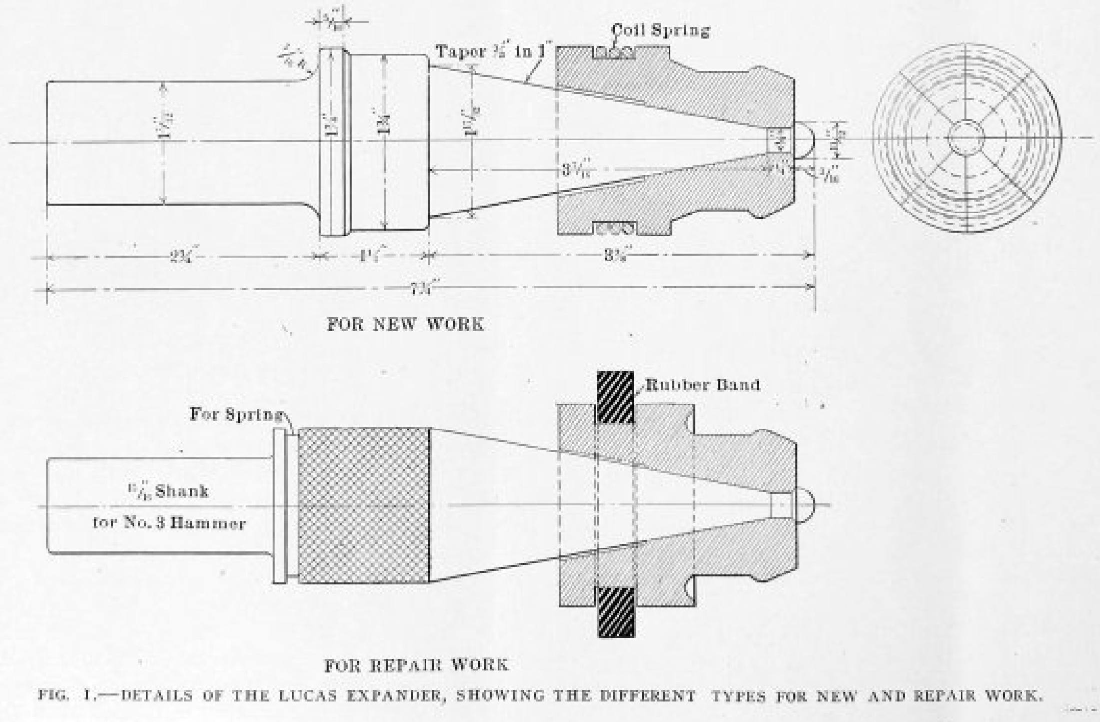


FIG. 1.—DETAILS OF THE LUCAS EXPANDER, SHOWING THE DIFFERENT TYPES FOR NEW AND REPAIR WORK.

in a recess of the handle next to the valve box. Since it is of unusually large diameter, it is less likely to become clogged up with dirt and thus cut down the air supply. When it does become clogged with dirt it can easily be removed and cleaned by blowing a jet of air through it in the opposite direction from that in which the air usually passes through it.

In regard to the economy of this tool, the manufacturers claim that, due to small clearance spaces, and the large ports of the air passages with a small diameter of valve, the air consumption is reduced from 20 to 30 percent over that in other makes of tools. Since all surfaces of the tool are hardened throughout, the wear is minimized and it is claimed that leakage is practically eliminated.

An Improvement on the Lucas Pneumatic Sectional Spring Tube Expander.

For several months there has been on the market a sectional tube expander which was invented by Mr. D. A. Lucas, foreman boiler maker of the Burlington & Missouri River Railway, at Havelock, Neb., the essential difference between this and other forms of expanders being that the mandrel has a relatively large taper and is so made that it will not stick in the

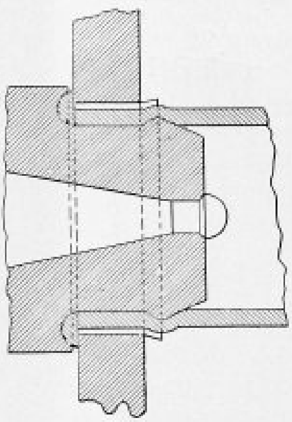


FIG. 2.—CORRECT STYLE OF LUCAS EXPANDER FOR REPAIR WORK.

sections. This expander was found to expand flues rapidly without injury to the tube sheet and could be operated by a small-size pneumatic hammer, since there was no necessity for using heavy blows.

An improvement has recently been made in this tool which makes it particularly adapted for repair work, since it not only expands the flue in the sheet but also tightens the bead and thus does away with the necessity of calking the bead.

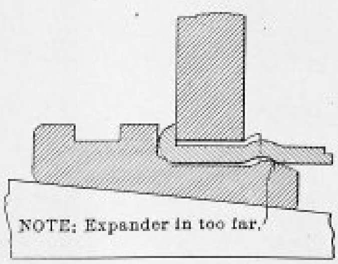


FIG. 3.—EFFECT OF USING OLD STYLE EXPANDER ON REPAIR WORK.

When expanding old flues on repair work with an expander which is intended for new work, the result obtained is far from satisfactory, since, as will be seen from Fig. 3, the expander does not fit the form of the tube. When the tube is expanded the second time the expander is driven in slightly farther, and the projection which should come just inside the tube sheet is brought against the straight part of the tube, and all the work is expended in enlarging this section of the tube.

The improved expander for repair work, for which patents have recently been applied, is slightly shorter than the expander used for new work, and thus the difficulty shown in Fig. 3 is overcome. The expander not only tightens the tube in the sheet but sets the bead up as well. Due to this flattening of the bead the shorter tool just fits the contour of the tube as formed when first expanded.

With the old method of expanding and beading it would usually take a man from 10 to 12 hours to set 350 flues, but with the new method it is claimed that the work can be done readily in 2 or 3 hours, and this with much less labor on the part of the workman, since he is using only a light air hammer instead of a heavy maul.

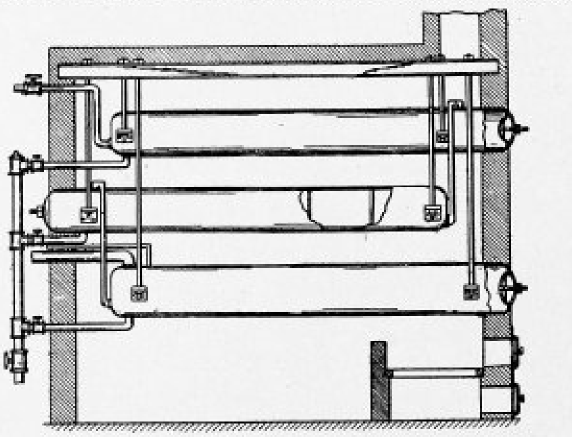
SELECTED BOILER PATENTS.

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.

843,613. STEAM-MAKING APPARATUS. Peter M. Knopp, Kansas City, Mo.

Claim.—The combination with a furnace casing having adjacent one end a fire-box and adjacent the other end a smoke-



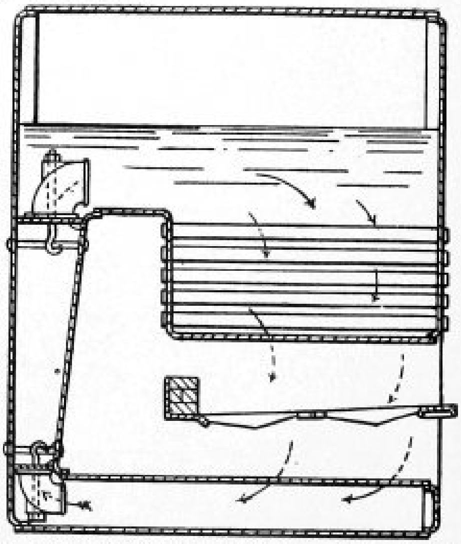
stack, of a plurality of boilers arranged in series in said furnace casing between the fire-box and the smokestack, water-conducting means connecting adjacent boilers, water-supplying means connecting with the boiler adjacent the smokestack, and means for conveying steam from the boiler adjacent the fire-box. Eight claims.

843,706. BOILER FEEDER. John F. Senter, of Chattanooga, Tenn., assignor to Senter Manufacturing Company, Chattanooga, a corporation of Tennessee.

Claim.—In an apparatus of the class set forth, a tank supported above the waterline of the generator and connected thereto only at the waterline so as to thereby be at all times filled with water while the water is above the waterline in the generator, a gravitating tank above the waterline and connected to the aforesaid tank so as to be kept normally filled with water and a pivoted lever for supporting the same, a weight on said lever normally tending to raise the tank and being of such weight that the tank when filled with water will overbalance it, flexible pipe connections between the gravitating tank and the stationary tank, and valve-operating means connected to said lever and adapted to operate when the tank is elevated by the weight. Four claims.

848,496. MEANS FOR PROMOTING CIRCULATION IN STEAM BOILERS. Sidney John Ross, of London, Eng., assignor of one-third to Harry Schofield and one-third to Oliver Prescott MacFarlane, of London.

Claim.—A wet-back marine boiler having its wet-back space inclosed at the sides, and provided at top with means for discharging water therefrom in a forward direction, so as to set up longitudinal circulation in the boiler, substantially as described. Six claims.

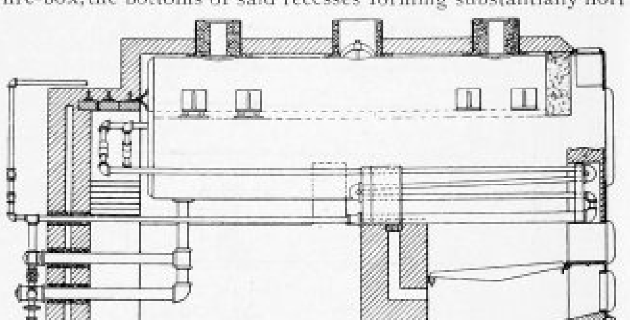


842,878. AUTOMATIC STOKER. John S. S. Fulton, New York, N. Y., assignor to Fulton Furnace Company, New York, a corporation of New York.

Claim.—In an automatic stoker, a step-grate comprising two inclined series of substantially horizontal grate bars, the bars of one series being interleaved between those of the other series, and means for producing relative upward, backward, downward and forward movements between alternate bars and the bars next above and below them, said movements diminishing in extent from the upper to the lower end of the grate. Twenty claims.

844,695. BOILER. Sidney Smith, of Cambridge, Mass.

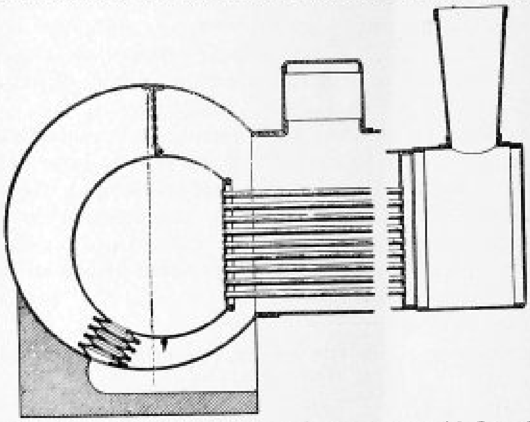
Claim. A boiler, a casing or setting therefore having longitudinal recesses in its walls at opposite sides of the boiler, and offset outwardly from the inner surfaces of the sides of the fire-box, the bottoms of said recesses forming substantially hori-



zontal shelves or seats extending lengthwise of the fire-box, and located outside the inner surfaces of the sides of the fire-box, return-bend feed-water-heating conduits located in said recesses, the lower members of said conduits resting on said shelves, and being adapted to expand and contract longitudinally thereon, clamps engaged with the said lower members, and supporting the upper members, whereby the upper members are permitted to expand and contract with the lower members, the latter being protected by the shelves against injury from the heat of the fire, and connections between the upper members of said conduits and a portion of the boiler higher than the conduits, the rear bends of the conduits being located adjacent to the bridge-wall, so that the length of the longitudinal members of the conduits is limited to substantially the length of the fire-box, and to the region of convected heat, whereby the flow of feed-water through said conduits is facilitated, and the formation of steam bubbles therein is prevented. One claim.

846,836. BOILER FURNACE. Harrington Emerson, of Topeka, Kan.

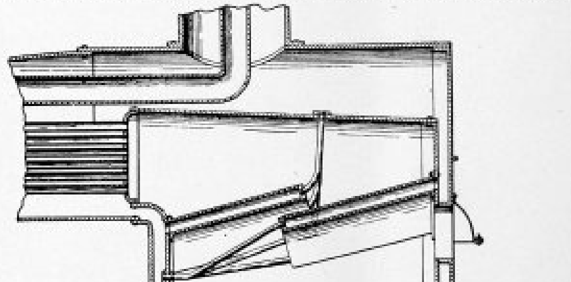
Claim.—In a boiler furnace, a fire-box inclosed in the boiler-shell and nearly surrounded therein by a water-space, said fire-box being movably suspended in the boiler-shell to have limited, independent expansion, contraction and movement therein, a flue-sheet forming one side portion of the fire-box, a flue-sheet secured to the boiler-shell adjacent to the smoke-box



and boiler tubes fastened at opposite ends to said flue-sheets. Seven claims.

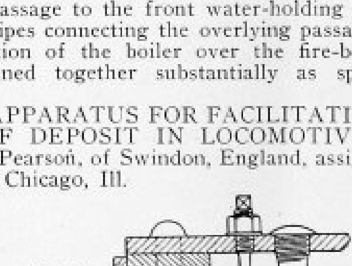
846,310. BOILER FIRE-BOX. Charles W. Hullings, of Philadelphia, Pennsylvania.

Claim.—A locomotive boiler having in its fire-box, above the grate, a rear downward-inclined arched water-passage attached to and communicating laterally and in rear with water-holding portions of said boiler, and a front upward-inclined arched water-passage, parallel to the first-named passage, and



attached to and communicating laterally and in front with water-holding portions of said boiler, the last-named passage overlying the first-named passage at or about the middle of the fire-box to provide a reverting-flue, pipes connecting the underlying passage to the front water-holding portion of the boiler, and pipes connecting the overlying passage to a water-holding portion of the boiler over the fire-box, said parts being combined together substantially as specified. Two claims.

847,435. APPARATUS FOR FACILITATING THE REMOVAL OF DEPOSIT IN LOCOMOTIVE BOILERS. Goeffrey H. Pearson, of Swindon, England, assignor to Albert C. Clark, of Chicago, Ill.



Claim.—A device of the kind described comprising an inverted-trough-shaped receptacle having its ends closed and having its side walls provided with apertures, substantially as described. Six claims.

846,234. FLUE CLEANER. William J. McCormick, of Trivoli, Ill.

Claim.—A device of the class described comprising a handle having a flattened head, a pair of forwardly-projecting spring-arms having their rear ends arranged to bear on opposite sides of the head, one of said arms being provided with a rearwardly-opening slot, fastening bolts entered through the head within said slot and adapted for detachably connecting the slotted arm with the handle and outwardly-projecting scraper blades attached to the forward ends of the arms. One claim.

THE BOILER MAKER

VOL. VII SEPTEMBER, 1907 No. 9

LOCOMOTIVE SMOKE-BOX ARRANGEMENTS.

BY E. W. ROGERS.

That portion of the locomotive boiler beyond the front tube sheet, known as the front end, or smoke-box, includes all the devices used for producing the draft in a locomotive. The layout of this part of the boiler is therefore of the utmost importance, since it determines in a great measure whether the boiler will steam at its rated capacity or not.

The front end includes the exhaust nozzle, diaphragm plate, netting door, stack and petticoat pipe. The exhaust nozzle is either a single or double pipe, usually made of cast iron through which the exhaust steam from the cylinders of the engine passes to the smoke stack. The upper end of the pipe is fitted with a nozzle, which is so arranged that it may be removed and replaced by another whose sectional area is greater or less as may be required, or which may be provided with an adjustable device by which the area of the opening may be changed while the engine is running.

Reducing the area of the exhaust nozzle increases the velocity of the exhaust steam, and therefore produces a stronger draft through the boiler. At the same time the restricted area of the nozzle causes an increase in the back pressure of the steam. Therefore, while it may be advisable at times to reduce the area of the exhaust nozzle so as to increase the draft, yet this frequently results in such an increase of back pressure as to affect the efficiency of the locomotive. Since the exhaust nozzle is a cast fitting it requires no laying out by the boiler maker.

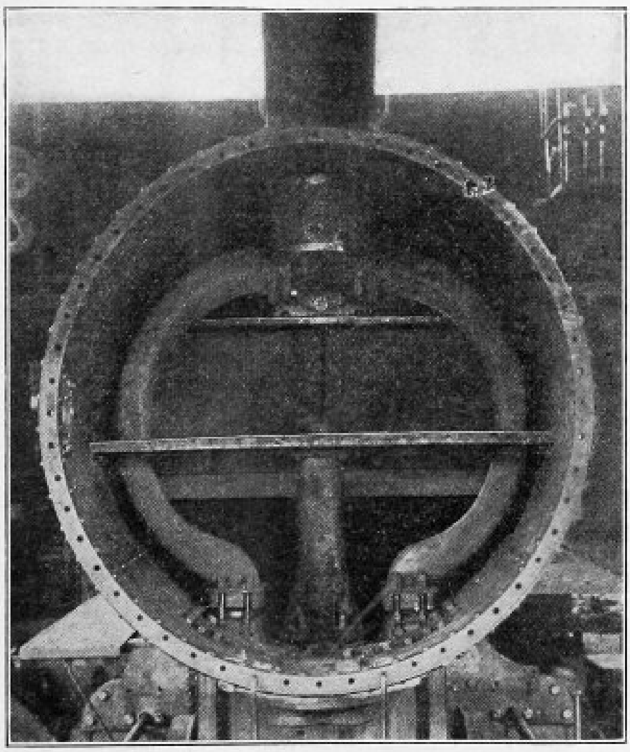


FIG. 1.—FRONT END OF LOCOMOTIVE BEFORE NETTING DOOR IS APPLIED.

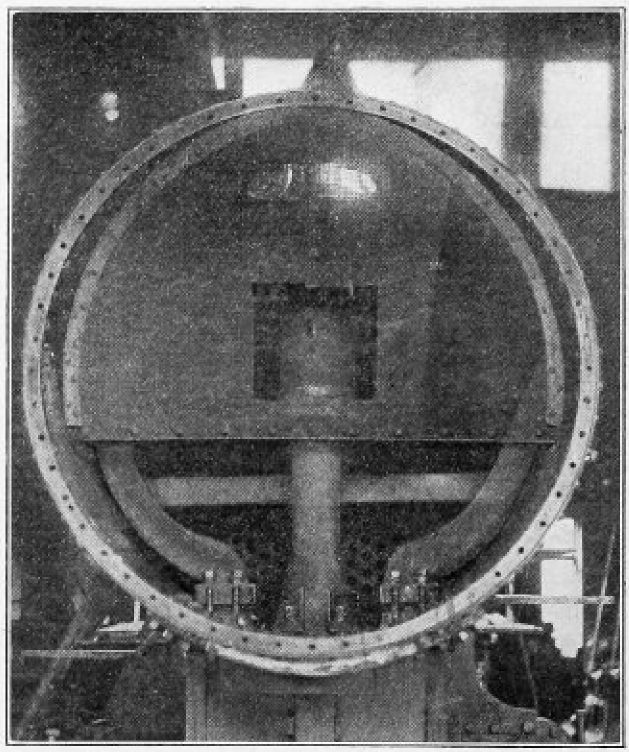


FIG. 2.—FRONT END OF LOCOMOTIVE, SHOWING NETTING DOOR IN PLACE.

The petticoat pipe is simply a cylindrical pipe which forms an extension of the stack down into the smoke-box. It is fitted with one or more cone-shaped rings, which may be raised or lowered with respect to the exhaust nozzle. Raising the pipe decreases the draft, while lowering it increases the draft, since it augments the induced action of the exhaust steam jet. The petticoat pipe presents no unusual problem in laying out, since it is a plain cylinder with a flared end.

The diaphragm plate is a solid plate attached to the tube sheet above the upper row of tubes and inclined downward at an angle of 20 or 25 degrees from the vertical. The diaphragm plate extends across the entire width of the smoke-

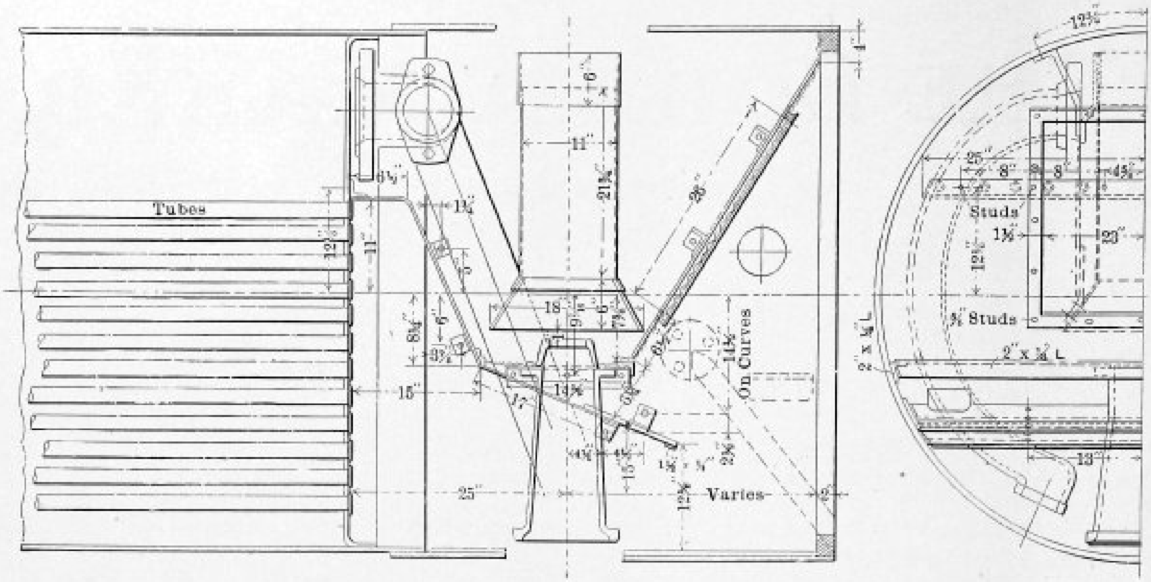


FIG. 3.—LONGITUDINAL AND CROSS-SECTIONS THROUGH SMOKE-BOX OF A 60-INCH LOCOMOTIVE BOILER.

box and also below the top of the exhaust pipe. At the lower edge of the diaphragm plate an adjustable slide is fitted, by which the area of the opening below the diaphragm plate may be increased or decreased. The action of this plate is such that the draft through the boiler is distributed equally through all the tubes, and by raising or lowering the slide the draft may be made stronger in different parts of the fire-box.

The deflection of the gases by the diaphragm plate causes the cinders and sparks to be broken up to a considerable extent. To prevent the further escape of cinders or sparks up the stack another inclined plate is fitted in the front end of the smoke-box which is fastened to the smoke-box shell plate and inclined downward to the rear. This plate is either perforated or made of netting, so that there will be sufficient area for the escape of the gases without retardation through the perforations.

The netting or perforated plate extends across the entire width of the smoke-box in the same way as the diaphragm plate. It has, however, a door fitted in the middle of it, which is usually hinged at the bottom and swings downward, so that a man may enter the space above the diaphragm plate for the purpose of cleaning or repairing.

No set rule can be stated to determine the proper height at which to set the slide on the diaphragm to obtain the best draft for a particular locomotive, since this depends upon the quality and kind of coal used, the size of the exhaust nozzle, etc. The main object is to get the draft from the nozzle distributed equally over the grate surface in the fire-box, variations being obtained by raising and lowering the slide on the diaphragm. "Drafting" an engine, or in other words, making her steam, is a tedious task and requires plenty of thought, close application and good judgment. The slide is usually so arranged as to produce a slightly stronger draft in the rear end of the fire-box than at the front end.

The layout of the diaphragm plate and netting door, two different styles of which are shown herewith, is a very simple problem, although the number of lines used in the layout appears confusing. It will be seen at once that we have a plane or flat surface intersecting a cylinder at an angle, the diaphragm and netting being simply flat plates and the smoke-

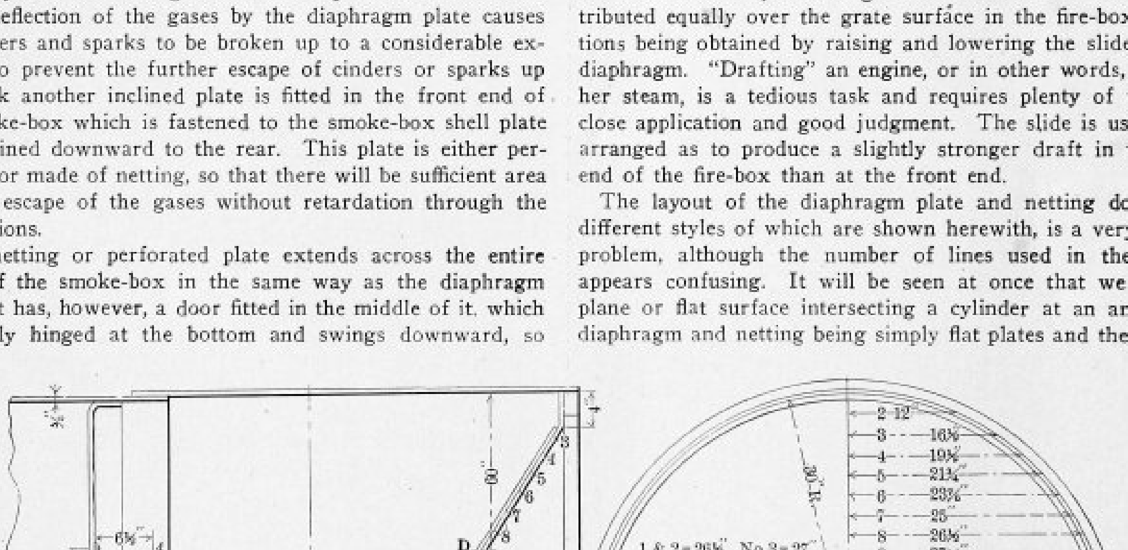


FIG. 4.—METHOD OF OBTAINING OFFSETS FOR LAYING OUT DIAPHRAGM PLATE AND NETTING DOOR.

box a cylinder. Take, for instance, the form of front end shown in Fig. 3. These cuts are taken from blue prints as they would come to the laying-out bench. This is all the information the layer-out gets from the drawing board. The details he must work out for himself. As time is money he cannot wait until the engine is built before getting these plates ready; he must plan ahead and give the workman his templet to work from at the proper time.

First, lay down on a table or plate a full-sized view of the front and side elevation of the smoke-box, diaphragm plate and netting door, eliminating all else on the layout. (See Fig. 4.) Let the different plates be *A, B, C, D* as shown, and divide each plate into any number of equal parts on the neutral axis or line through the center of the material; extend the dotted lines through these points parallel with the center line of the boiler over to the front elevation, as shown in the different sections *A, B, C* and *D,* and number them in any convenient manner.

First take the section *D,* which is the netting door. As this is divided into seventeen equal spaces in Fig. 4, beginning at the top of the smoke-box (Fig. 5), lay down seventeen equal spaces on the center line of the plate (or netting); this gives the length of the plate. Draw through these points dotted lines at right angles to the center line and lay off on each the length as measured from corresponding lines in Fig. 4. Dimensions are given in each case so that an apprentice will have no trouble in following this part of the work. A curved line drawn through the points so located gives the true shape of Section D.

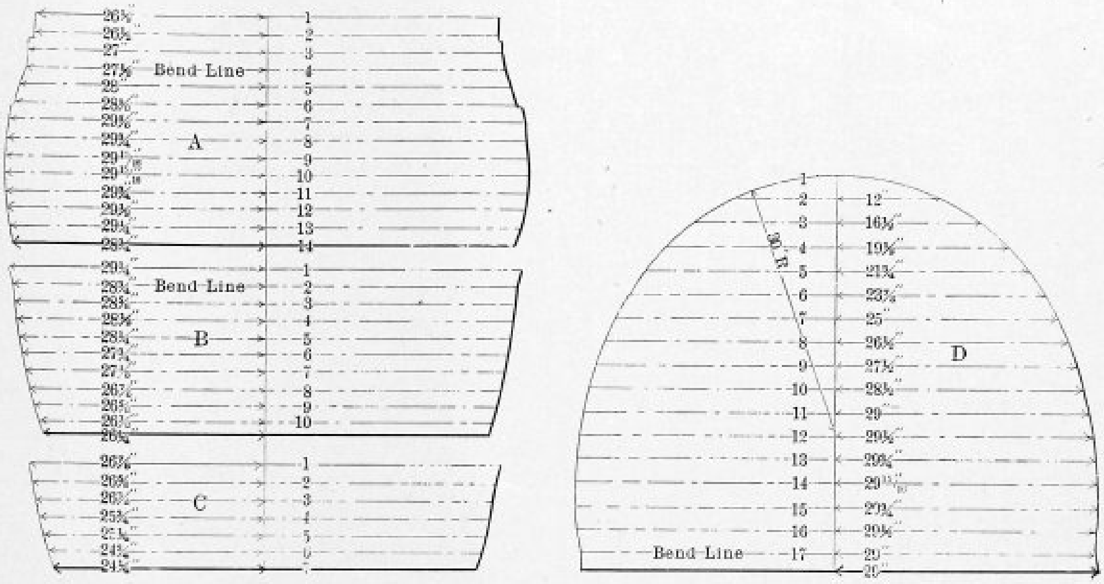


FIG. 5.—LAYOUT OF DIAPHRAGM PLATE AND NETTING DOOR FOR 60-INCH BOILER.

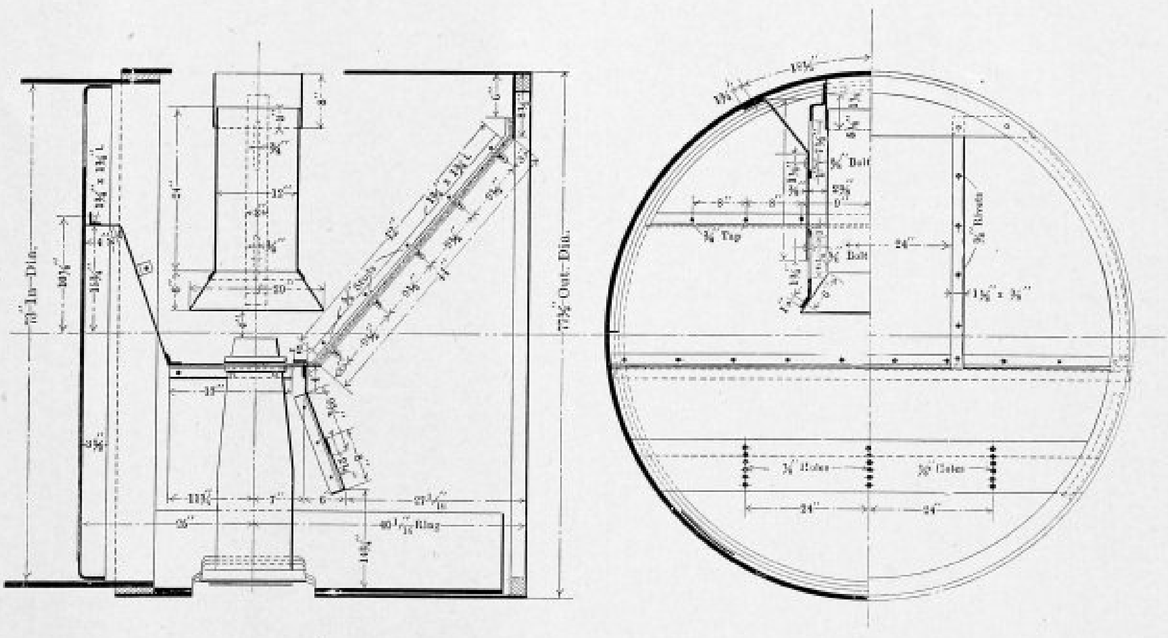


FIG. 6.—SECTIONS THROUGH SMOKE-BOX OF A 73-INCH BOILER.

The plates are usually made ⅛ inch less in extreme width at each point on account of the variations in the diameter of the smoke-box, which is seldom exactly round. The radius

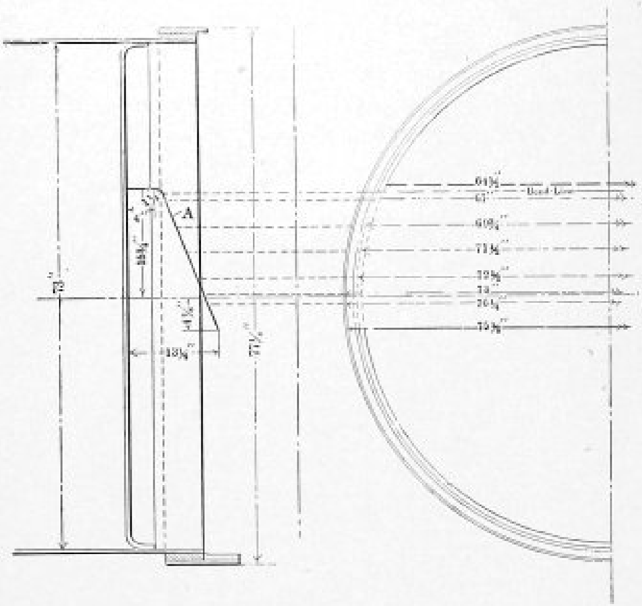


FIG. 7.—OFFSETS FOR DIAPHRAGM PLATE, 73-INCH BOILER.

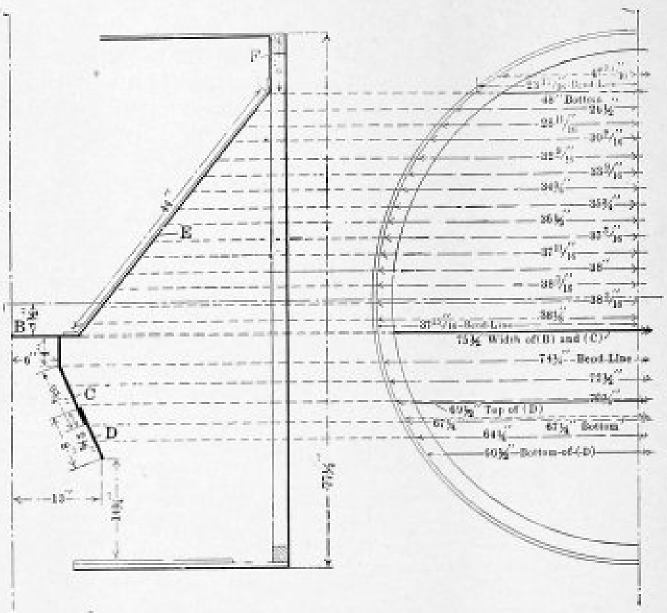


FIG. 8.—OFFSETS FOR SLIDE AND NETTING DOOR, 73-INCH BOILER.

in this case is given as 29 15/16 inches; this gives 1/16 inch clearance all around.

Sections *A*, *B* and *C* are laid out in a similar manner, as shown in Fig. 5. Care should be taken to cut the plate out to allow for the flange of the front tube sheet and also the first course of the shell of the boiler, as shown in the upper corners of section *A*. Lines 1 and 2 are measured to the inside diameter of the flange of the head. Lines 3, 4, 5 and 6 are measured to the inside diameter of the boiler shell, all the other lines being measured to the inside diameter of the smoke-box. The lines on which the plate is to be bent are indicated so that when the sections are cut out and bent to shape they will fit to perfection.

The diaphragm plate and netting door are secured to the tube sheet and smoke-box shell by angle-irons. The plates must be made in two sections, the seam running along the center line of the pattern. This is necessary, since the steam and exhaust pipes are fitted in the boiler first and, therefore, the plates which fit around them must necessarily be in two parts in order that they may be fitted in place.

In Fig. 6 a slightly different form of front end arrangement is shown. The diaphragm plate extends from above the tubes to the horizontal plate fitted just below the exhaust nozzle in the same manner as in the preceding arrangement. The diaphragm slide, however, is fitted in front of the exhaust nozzle upon the plate *C*, which is attached to the horizontal plate with an angle-iron. The netting door is arranged in much the same manner in this locomotive as in the preceding one.

As the drawing shown in Fig. 6 is the form in which the blue print comes to the laying-out bench, the layer-out must get all his information from this and proceed with the development of the individual parts in the same manner as before. Lay out on the table or bench, Figs. 7 and 8, full size, and divide the length through the center of the plates into any number of equal parts, drawing horizontal lines from these points across to the front elevation and measuring the off-sets from these lines. The development of the diaphragm plate *A*, the horizontal plate *B*, the diaphragm extension *C*, and the slide *D* are shown in Fig. 9, while the netting door and the plate to which it is attached are shown in Fig. 10.

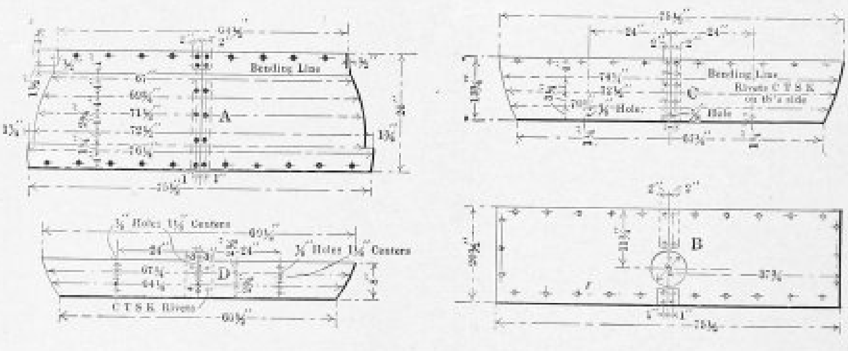


FIG. 9.—DEVELOPMENT OF DIAPHRAGM PLATE AND SLIDE FOR 73-INCH BOILER.

All the dimensions are placed on these plates so that an apprentice may easily follow through the layout. The rivet holes and center seams are also shown in detail. Light plates may be used in all this work as these plates do not add to the structural strength of the boiler nor are they required to withstand any pressure. The exact shape of all pipe openings may be obtained by cardboard templets taken from the particular boiler under construction.

The preceding examples are typical types of smoke-box arrangements which are in use to-day, and the method used in laying out these plates may be applied to any arrangement, even though its details differ considerably from those shown in either of the above cases.

Causes of Leaks in Locomotive Boiler Tubes.

The boiler maker seems to have been exonerated from the blame which is usually placed upon him for leaky tubes in locomotive boilers, according to a report made by Mr. M. E. Wells at the recent convention of master mechanics. Regarding the mechanical causes of leakage, which include defective work at the time of first setting the flues, poor hurry-up work in running repairs, vibation of the tubes and wearing out of the tube ends by the abrasive action of the cinders; he states that almost any kind of a job of tube setting, which may be done by an apprenticed boy in the front end of the locomotive, will hold from one shopping of an engine to the next, while the work as it is usually done by a skilled boiler maker gives practically no cause for trouble. The remedy for the second cause of leakage, which is one of the greatest sources of trouble, is plainly to take the time to do the repair work well. Leaks

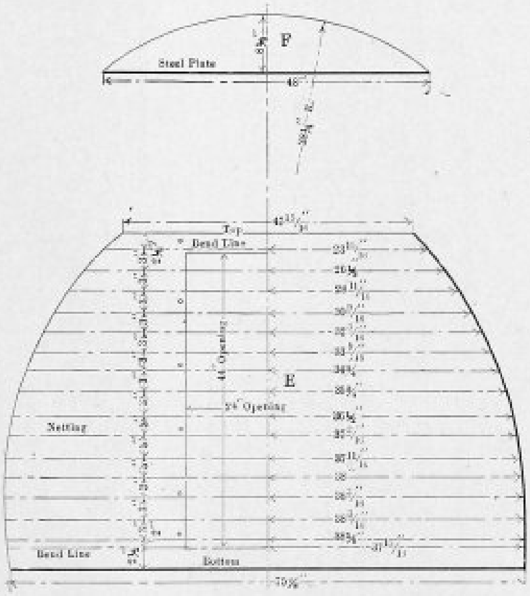


FIG. 10.—DEVELOPMENT OF NETTING DOOR FOR 73-INCH BOILER.

due to the vibration of the tubes are unimportant, and those due to wearing out of tube ends by the cinders may really be attributed to variations in temperature.

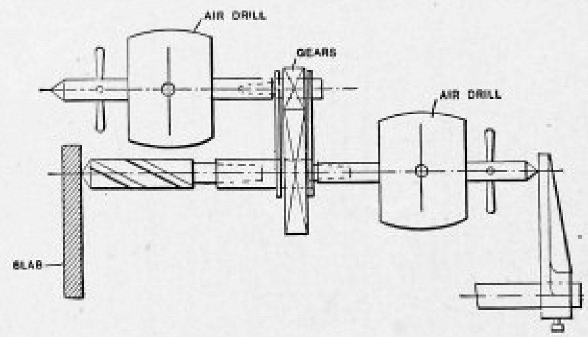
The most important cause of leaks he considers to be the variations in temperature due to the feed-water. There is little opportunity for leaks to occur even if the tube ends and tube plate are heated up and cooled down a number of times, if they are heated and cooled uniformly; but there is every opportunity for leaks when these parts are subjected to varying degrees of heat in different places. The cause of unequal variation of temperature in the tubes and tube sheets has frequently been attributed to the cold air which is drawn through the fire-box and which strikes the tube sheet. Engines in which cold air has effectually been prevented from striking the tube sheet have been found to leak just as badly as those in which the lower part of the sheet is not protected by an arch. Thus the defect can only be ascribed to the differences of temperature caused by the cold feed-water entering the boiler at intervals.

The remedy for this defect is at once apparent, namely, to heat the feed-water. To do this injectors will have to be given up and feed pumps substituted, and also some form of feed-water heater must be installed in the tanks. The London & Southwestern Railway, of England, has tried this arrangement, replacing all injectors which required renewing by duplex pumps, and heating the feed-water by exhaust steam passing through steel tubes in the water tanks. When a train leaves a terminal station the pumps are started and kept constantly at work until the train is stopped. This constant feed prevents any sudden change in temperature of the water in the boiler. The feed-water enters the boiler through the smoke-box, and the result has been that there is very much less trouble from leaky flues, and consequently much less expense for repairs between trips.

Compounding an Air Drill.

A contributor to a recent issue of "Machinery" describes the following method of doing a job of heavy drilling which might be found useful in some emergencies in boiler or structural work.

We had some 2 15/16-inch holes to drill in a 1½-inch slab, and as it was a repair job the work had to be done in place, using an air drill. We started in one Sunday morning with the largest air drill obtainable, which was intended to drill 1½-inch holes at the maximum, and that drill didn't allow the original intentions of its designer to be perverted, either. To begin with, the throttle was out of order, and we could neither start nor stop it except from the valve at the air plug, way across the shop; when the man at the drill and the man at the valve finally got the word together, it started off nicely for a few



ARRANGEMENT FOR USING TWO AIR MOTORS ON ONE DRILL FOR HEAVY WORK.

minutes, until the overload became too great; then there was a short imitation of an automobile going up hill, and silence, with an accompanying lack of rotation on the part of the drill. The boss looked it up and decided it would have to go to the shop for repairs; by the time he got a ratchet and half a dozen "Hunkies" on the job it was 5.30, and we went home.

By the next Sunday (the only day in the week that the shop shut down) we had rigged up two air drills as shown in the sketch, gearing them together; this was done by keying two gears, in the ratio of three to one, on the drill sockets, with a steel plate on each side of the gears to keep the proper center distance and bind the tools together. The main air drill, that is, the one in line with the drill itself, was held in place by an "old man" and fed in the ordinary way; the other, the upper one in the sketch, was lashed to the first with ropes, twisted tight in order to get the necessary pull. Half-inch holes were first made in the slab with a single drill, and the new apparatus put into commission. After a little experimenting it took hold and put those 2 15/16-inch holes through just as well as an up-to-date radial would have done it in the shop.

Of course, the full power was not gotten out of the direct-working air drill, as it could not work up to the limit of its speed; but the work was done, and that was all we cared about.

Methods of Supporting the Tops of Combustion Chambers in Marine Boilers.

The method which has been most generally used for bracing the top of the combustion chamber in a marine boiler is shown in Fig. 1. A number of girders which are supported at each end on the flanges of the tube sheet and back plate of the combustion chamber form a support for a number of stay-bolts which are spaced at regular intervals in the crown sheet of the combustion chamber. The girders are made in a variety of ways, sometimes consisting of two plates riveted to blocks at either end, which serve to keep the plates apart and thus permit the stay-bolts to pass between them. Frequently the plates are shaped to form the bearing on the tube sheet and back plate, the block at the ends serving merely to keep apart the two plates which form the girders, or the blocks may form the bearing surface on the tube sheet and back plate.

The stay-bolts are suspended from the tops of the girders by means of short clips and are usually provided with nuts inside the combustion chamber and at the upper end of the bolt.

This form of construction was deemed impractical by the United States Board of Supervising Inspectors, for the reason that the entire pressure on the top of the combustion chamber was thrown upon the flanges of the tube sheet and back sheet, making it necessary to use heavier material for these sheets than would be necessary simply to withstand the steam pressure. In their general rules and regulations for the inspection and construction of boilers, as amended January, 1906, the Board of Supervising Inspectors recommended that the tops of the combustion chambers and back connections in all boilers whose construction was commenced after June 30, 1906, subject to a pressure of 160 pounds per square inch and over, should be suspended from the top of the shell. Where girders were used in the construction of tops of combustion chambers and back connections, such girders should be suspended by braces from the top of the shell to the girders, each of such braces to be of a sectional area not less than twice the sectional area of each of the bolts suspending the top of the combustion chamber from the girders.

This radical change in construction aroused a good deal of opposition on the part of boiler manufacturers, and has this year been retracted. Certain methods of bracing this part of the boiler are, however, recommended, and illustrations are given to show the advantage of using sling stays either alone or in connection with the girder system.

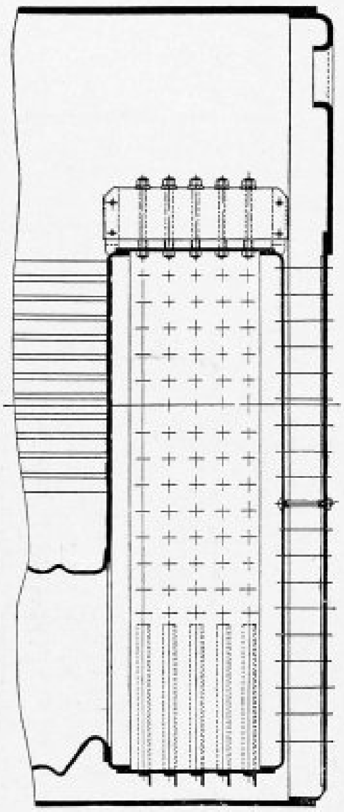


FIG. 1.—ORDINARY METHOD OF SUPPORTING TOP OF COMBUSTION CHAMBER.

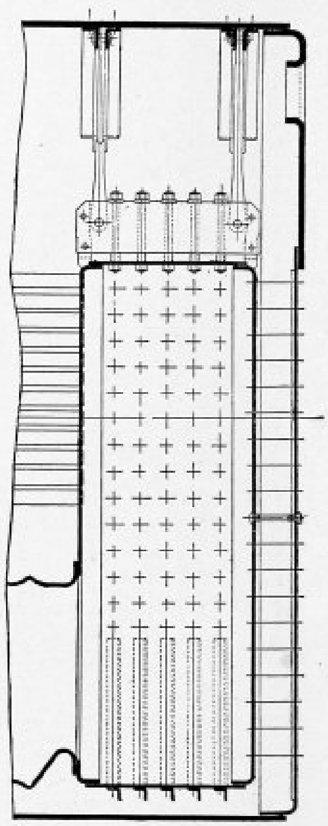


FIG. 2.—WEIGHT OF COMBUSTION CHAMBER AND FURNACES SUPPORTED BY SLING STAYS.

Fig. 2 shows a construction recommended for separate combustion chambers which are not secured to the shell at the bottom, and are therefore liable to bend the small screw stays. The ordinary form of girder bracing is used, but sling stays are also provided, which are fastened at each end of the girder with hangers of sufficient diameter to carry the weight of the combustion chamber and one-half of the tubes and furnaces when no water is in the boiler. In this case the tube sheet and back plate must carry the full compressive load, due to the steam pressure, in the same manner as in a boiler without the sling stays.

When the top of the combustion chamber is supported, as shown in Fig. 3, the thickness of the tube sheet and back plate may be materially reduced from that required when the tube sheet and back plate must sustain the full compressive load, providing that the bottom of the combustion chamber is well stayed by girders of plates and angles. In this case the sling stays take the full compressive load off the tube sheet and back plate except that half of the load on the unsupported portion marked *B* beyond the stay will be taken by the tube sheet and back plate, respectively.

The girders may be left out entirely, as shown in Fig. 4. In this case the sling stays sustain the full compressive load except that half of the load on the unsupported portions marked *B* beyond the stays will be taken by the tube sheet and back plate, respectively. The bottom stays, where there are screw stays or girders of plates and angles, must be of at least the same sectional area as the top braces.

How to Drive Steel Rivets by Hand.

BY HENRY MELLON.

Let us consider driving up the furnaces of a two-furnace marine boiler the plates of which are to be 3/8 inch thick.

The rivets will be 3/4 inch diameter and 1 7/8 inches long. The rivet holes should be only 1/32 inch larger in diameter than the rivets, or 25/32 inch. All the furnace rivets should be driven on the inside or the fire side. The tools necessary for single-handed riveting are a balled-face hammer, 3 1/4 pounds in weight, with a handle 17 inches long and a face 1 3/16 inches in diameter, ground sharp and straight across the face; a beveled faced hammer weighing 3 pounds, whose body is 1 5/16 inches square and which has two faces 1 inch in diameter ground very sharp; a drift pin; a half-round 3/4-inch reamer; a 3/4-inch wrench and a button-set hammer weighing about 7 pounds, with the two faces a little rounding. The holder-on should have a steel sledge not less than 20 pounds weight, with a wooden handle 8 feet long, or as near that as he can use. This sledge should be used wherever possible, but when it cannot be used then use a 16-pound wedge bar with a handle 1 3/8-inch diameter and about 72 inches long.

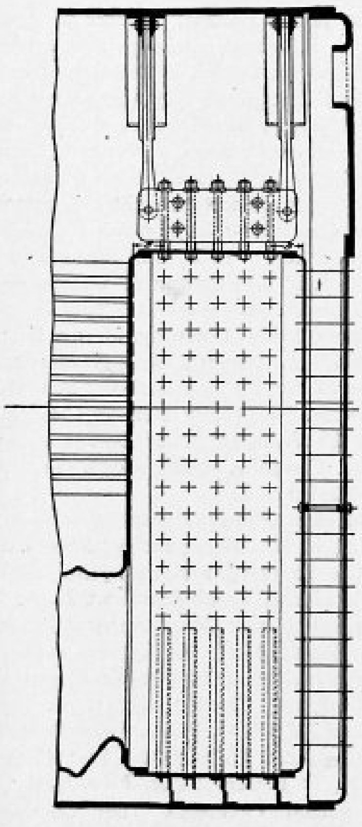


FIG. 3.—NEARLY ALL OF COMPRESSIVE STRESS SUSTAINED BY SLING STAYS.

Now, sign out to the bucker-up to get over the rivet hole, putting your drift pin in the hole to show him which one to get over. Let the holder-on put a cold rivet in the rivet hole, if he must use the wedge bar, and put his wedge on the rivet head. He can hold on more solidly over the holes this way with a bar; now, with the 7-pound hammer lay up the plates and screw up the bolts near the hole at which you intend to begin driving. Keep plenty of bolts in the work and keep it well closed up. This is half of the secret of doing good work, for close plates will not allow the rivets to break off at their heads. Have a pair of common tongs and a spring tong at the place where the rivets are to be put in. If the riveting is on a flange, take a chisel and chip the back side of the rivet holes a little countersunk, not entirely around the hole, however. This will let the off side of the rivet go down to the sheet better. Now, rattle for the rivet heater to come on with a rivet.

When the rivet comes in the hole and the bar is on it, plug it in straight into the hole, and when it begins to spread on the plate strike it with the ball of your hammer so as to scoop the hot steel or rivet right down to the sheet, and also shape the rivet, keeping it up high, say, 11/16 inch.

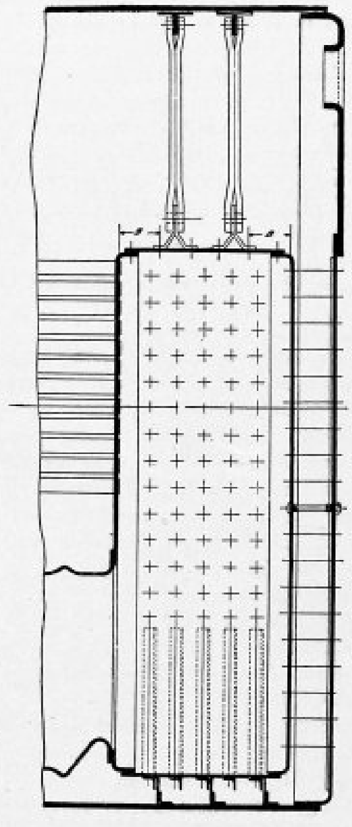


FIG. 4.—GIRDERS OMITTED, SLING STAYS CARRY PRACTICALLY ENTIRE LOAD.

After you have it shaped tell the holder-on to put a cold rivet in the next hole and put his wedge on this rivet. Hammer up the plate or flange with the 7-pound hammer, and then tell the holder-on to put the cold rivet in the hole on the other side of the rivet which you have just shaped, when you hammer up this side of the hole on the flange or seam in a like manner. Now, let the holder-on get on the rivet that you plugged, and go around with your balled-face hammer for ten or fourteen blows. Next take the bevel-faced hammer and work the rivet to the sheet, finally cutting it into the sheet. Don't, however, butcher or carve the plates with the sharp hammer face.

Drive all the rivets in the same manner as the first one, and let your partner do the same with his single-handed side. Now-on the double-handed riveting, the holder-on uses the same tools, but the two riveters each want a 7-pound hammer with which to close up the plates and a 3¼-pound hammer for driving. The latter should have a body 1 5/16 inches square, and a face 1 1/16 inches diameter ground flat. Be sure that the rivet hole is fair, and after the plate is hammered up all around the rivet hole rattle for a rivet. When it comes in the hole plug it with the 1 1/16-face of the hammer, and when it begins to spread on the plate the right-hand man should begin to strike on the bottom of the rivet, the left-hand man striking on the top, so that the two will make the head look like a "V" or wedge. As the right-hand man works up towards the middle of the rivet, on the side away from him, when he gets up over the middle he is still working around it towards the top, but when he passes the middle then the left-hand man drops his hammer in a graceful swing, and strikes at the bottom of the rivet and works up. When he gets up over the center on the side away from him the right-hand man drops his hammer in a graceful swing and strikes at the bottom again, and working from there up to the top of the rivet. After going around the rivet in this way five or six times the left-hand man stops while the right-hand man turns his hammer over and using the sharp side works the edge of the rivet into the plate. After he has gone nearly around it once his partner comes in at the bottom in a like manner, and they alternate until the edge of the rivet is driven into the plate. This completes the job, and if the work has been well done the rivet will not leak or require any further calking.

Programme of the Nineteenth Annual Convention of the A. B. M. A.

The nineteenth annual convention of the American Boiler Manufacturers' Association of the United States and Canada will be held at Atlanta, Ga., Oct. 8, 9 and 10, 1907. The Atlanta entertainment committee has already been formed and is in good working shape. Definite plans for the meetings and the programme for entertainment of members and guests are nearly completed. The convention will open at the Piedmont Hotel, 10.30 A. M., Oct. 8, in the Assembly Hall. An address of welcome will be delivered by Mayor W. R. Joyner. In addition to the annual address by Col. M. F. Cole, president of the association, addresses will be made by Col. E. D. Meier, president of Heine Safety Boiler Company, New York, and W. H. S. Bateman, Southern representative of the Chicago Pneumatic Tool Company.

Tuesday afternoon, business session, at 2.30 P. M.; trolley ride around Atlanta for the ladies, stopping en route at the Piedmont Driving Club for luncheon.

Tuesday evening, convention theater party.

Wednesday morning, business session, 9.30 A. M. Ladies will visit stores and take part in individual sightseeing trips.

Wednesday afternoon, at 1.00 P. M., the entire convention, with invited guests, will leave the Atlanta Terminal Station in a special train on a 40-mile trip to Newnan, Ga., via the famous Atlanta & West Point route. On arrival at Newnan, the train will be run into the works of the R. D. Cole Manufacturing Company. After an inspection of the works the trip will be continued to Pearl Spring Park, where the entire party will be served a genuine Georgia barbecue. In addition an opportunity will be given the guests to witness the evolution of cotton from the field to the finished product—cotton growing in the field—cotton picking—cotton ginning—cotton spinning and weaving—returning to Atlanta by 6.00 o'clock.

Wednesday evening, entertainment not yet decided upon.

Thursday morning, business session, 9.30 A. M. Ladies will be taken on a trolley trip over the famous scenic route of the Atlanta Northern Electric Railway, a 20-mile ride, crossing the Chattahoochee River en route to the historic town of Marietta, Ga., where the battle of Kennesaw Mountain was fought, and visiting the National Cemetery, where upwards of 15,000 soldiers are buried.

Thursday afternoon, business session, 2.30 P. M.

Thursday evening, at 8 o'clock sharp, the annual banquet will be held, which will close the convention.

Information in regard to the reservation of rooms and any other matters in connection with the convention may be had by addressing E. M. Cole, secretary of entertainment committee, 316 Empire building, Atlanta, Ga.; M. F. Cole president A. B. M. A., Newnan, Ga.; Harvey & Wood, Piedmont Hotel, Atlanta, Ga.; J. D. Farasey, secretary A. B. M. A., Cleveland, Ohio; W. O. Duntley, president Associate Members A. B. M. A., Fisher building, Chicago, Ill., and W. H. S. Bateman, secretary of Associate Members, 820 Arch street, Philadelphia, or THE BOILER MAKER, 17 Battery Place, New York City.

It is understood that a great many members and their friends from the Central West, North and New England States, propose coming to Atlanta via steamer from New York to Savannah, thence by rail to Atlanta, in order to take advantage of the ocean trip. Information in regard to sailing of steamers and reservation of rooms may be had by addressing Mr. Thos. Aldcorn, general Eastern sales agent, Chicago Pneumatic Tool Company, 95 Liberty street, New York City, or Mr. Henry J. Hartley, superintendent boiler department Cramps Shipyard, Philadelphia, Pa.

The general entertainment committee is composed of representatives of the following firms, which are all Southern members of the association: R. D. Cole Manufacturing Company, Newnan, Ga.; John J. Finnigan & Company, Atlanta, Ga.; George R. Lombard Iron Works & Supply Company, Augusta, Ga.; J. S. Schofield Sons Company, Macon, Ga.; John Rourke & Son and William Kehoe & Sons, Savannah, Ga.; Valk & Murdoch Iron Works, Charleston, S. C.; Merrill-Stevens Company, Jacksonville, Fla.; Casey & Hedges Manufacturing Company, Walsh & Weidener Boiler Company, Lookout Boiler Manufacturing Company, Chattanooga, Tenn., and Marion Iron Works, Marion S. C.

The Atlanta entertainment committee consists of J. Stewart Cole, chairman; E. M. Cole, secretary; Messrs. W. M. Francis, W. H. L. Nelms, Samuel J. McGarry, John J. Finnigan, Horace Parker, V. A. Moore, Frank Harrison, F. A. Dillworth and others, in connection with the regular standing executive committee of the Supply Men's Association, consisting of W. O. Duntley, vice-president and general manager Chicago Pneumatic Tool Company, Chicago, Ill.; H. B. Hare, Otis Steel Company, Cleveland, Ohio.; W. H. S. Bateman, Chicago Pneumatic Tool Company, Philadelphia, Pa.; George Slate, THE BOILER MAKER, 17 Battery Place, New York; H. S. Covey, secretary Cleveland Pneumatic Tool Company, Cleveland, Ohio; E. A. Downey, National Tube Company, St. Louis, Mo.; C. A. Hunt, Worth Bros. Company, Cincinnati, Ohio; D. J. Champion, Champion Rivet Company, Cleveland, Ohio; W. L. Hirsch, American Steel & Wire Company, Pittsburg, Pa.; Columbus Dill, Ashton Valve Company, Boston, Mass.; R. S. Groves, Worth Bros. Company, Philadelphia, Pa.; George Bentley, Central Iron & Steel Company, Harrisburg, Pa.; L. A. Hennock, Joseph T. Ryerson & Company, Chicago, Ill.

W. H. S. BATEMAN,
Secretary of Associate Members and Supply Men's Association, A. B. M. A.

Erratum.

On page 231 of our issue for August the equation $H. P. = 3.33 (A - .6 \sqrt{H}) \sqrt{H}$ should read:

$$H. P. = 3.33 (A - .6\sqrt{A}) \sqrt{H}.$$

Piping and Fittings for a Tubular Boiler.

BY F. C. DOUGLAS WILKES.

PART II.

The Dry Pipe.

In connection with the steam outlet of a boiler there is usually some arrangement made whereby the steam drawn from it is freed as far as possible from the particles of water suspended therein, which would cause trouble if allowed to get to the engine. There is, of course, the "separator," which is usually placed in the steam line close to the engine, but there is also provision made in the boiler itself to separate the steam from the water.

In Fig. 7 is shown a very simple and usually effective way of doing this. This separator, or "dry pipe," as it is called, should be for the boiler under consideration (60 inches by 14 feet) about 5 feet long, 8 inches wide and 6 inches deep. On the two sides are punched rows of holes from 3/8 to 1/2 inch in diameter. The area of these holes should aggregate at least two to three times the area of the steam outlet, so that the passage of the steam through them will not be hurried nor restricted. The material used is No. 12 or No. 14 gage sheet iron, and it is held in place against the top of the shell by three or four rivets on either side. Some makers put separating washers on these rivets, thereby leaving a narrow space around the top between the shell and the dry pipe.

The writer knows of one instance at least where the boiler with a dry pipe made with an open strip around the top gave a good deal of trouble by priming. The steam space was rather limited, and it was suggested that the water was drawn by the steam (aided by capillary action) around the shell through this opening into the steam pipe. Whether this was the case or not, this dry pipe was removed and one similar to the one shown in Fig. 8 was put in. The boiler, since then, has given no trouble, by priming, so it would appear there was some truth in the suggestion as made above.

The ends do not have to be absolutely water tight, nor the work expensively careful, the main idea being to form a series of corners that the steam must turn, thereby throwing out the suspended particles of moisture by centrifugal force.

A more elaborate form of dry pipe is shown in Fig. 9. *S* is the steam pipe, a branch of which passes through the casting *A*, which fits snugly about it and is held in place by the set screw *B*. *C* is the dry pipe proper, and is about two or three sizes larger than the steam pipe. This is threaded on each end, one end being furnished with a plug or cover and the other screwed into the casting over the steam pipe. The pipe *C* is perforated as usual above its center line, but there are no holes for some distance on either side of the end of the steam pipe, as shown by space *D*. The ends of this pipe are stayed to the boiler with stay-bolts, as shown, and when the pipe *S* is of considerable length this pipe is centered in the dry pipe by means of two or three set screws, as shown in the sectional view at the left of Fig. 9.

These separators or dry pipes are largely responsible for the modern practice of making boilers without domes, as they perform practically the same office and are considerably less expensive to make.

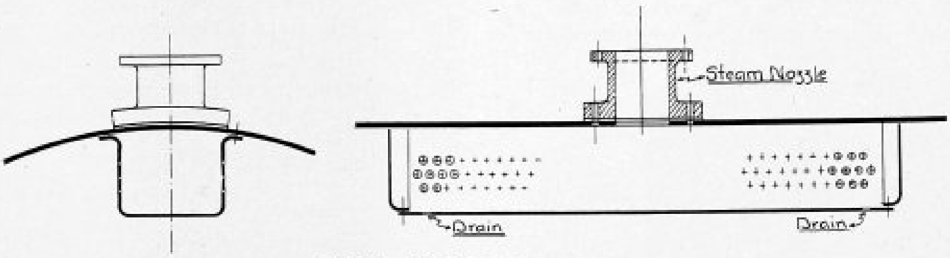


FIG. 7.—BOX FORM OF DRY PIPE.

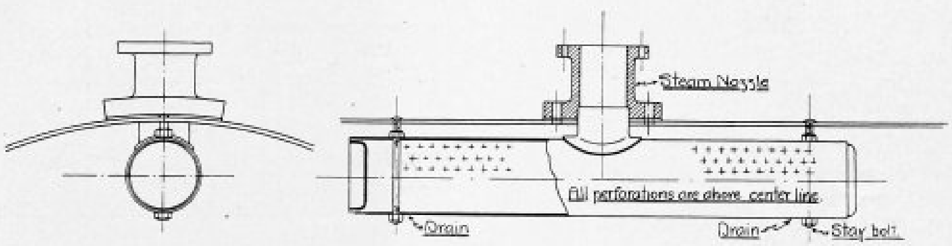


FIG. 8.—CYLINDRICAL DRY PIPE.

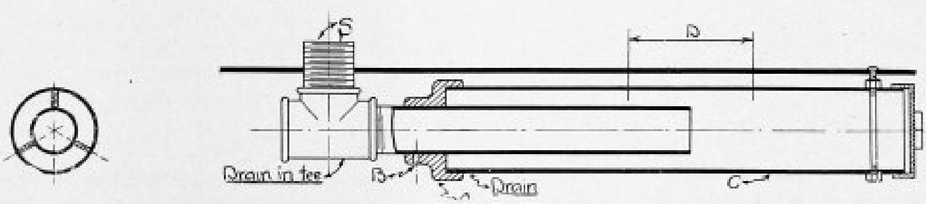


FIG. 9.—DRY PIPE IN WHICH THE STEAM PIPE IS ENTIRELY SURROUNDED.

The Blow-Off.

As the water fed to boilers is always more or less impure, and as there is also a precipitation of solid matter on account of the high temperature of the water in the boiler, there must be some arrangement made for cleaning the boiler when in service and for getting rid of these impurities or solid matter. This function is performed by the "blow-off." There should be two furnished, one to take care of the solid matter which sinks and one to take care of the lighter substances which float on the surface. The former is placed at the bottom of the boiler near the back head (which is always set an inch or so lower than the front), and the other one in the back of the boiler, either at or a little below the water line. The openings should be ample, and pipes leading from them furnished with a special valve, which is generally of the plug type, as there is less liability of valves of this type becoming clogged by the passage of sediment through them. The pipes should lead as directly as possible to the place of discharge with the least possible number of bends in them.

The scum cock, as the top blow-off is usually called, may have an area equal to the evaporative power of the boiler in

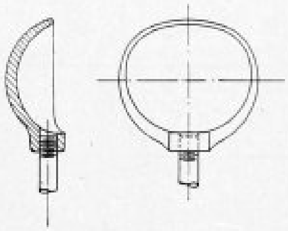


FIG. 10.—CUP-SHAPED SCUM BLOW-OFF.

pounds of water per hour × .00053. The boiler end of the scum blow-off pipe is usually funnel or cup-shaped, as shown in Figs. 10 and 11.

The bottom blow-off should have a little larger area than the upper one, and it is found by multiplying the evaporative power of the boiler in pounds of water per hour by .00082.

The blow-off cocks are preferably of gun metal or similar metal, and if made of cast iron they should have linings of this metal for the plugs to work in, the plugs themselves being of the same metal as the linings.

The taper of the plugs in scum cocks should be about 1 in 8. For blow-off cocks up to 90 pounds steam pressure 1 in 6; up to 180 pounds steam pressure 1 in 8; for higher pressures 1 in 10. As blow-off cocks are liable to stick fast they should be opened regularly, and the plugs should be kept clean and the stuffing boxes always adjusted.

Fig. 12 shows the relative position of the scum and blow-off cocks leading to the same discharge point. Although it is

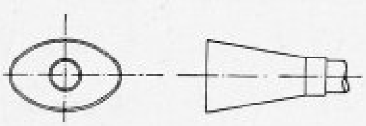


FIG. 11.—FUNNEL-SHAPED SCUM BLOW-OFF.

better to have the scum blow-off pipe coming out directly, as shown by the full lines, if the back arch or brick work interfere, it may be brought out, as shown by the dotted lines, without much loss of efficiency. Sometimes the system is arranged as shown in Fig. 13, in which, if the cocks *A* and *B* are opened and *C* closed there will be a circulation through the pipes tending to keep them clean. At the same time either one can be used independently of the other if so desired.

The Injector.

Now, we will consider the ways of replenishing the water in the boiler to make up for the steam used. We may either use an "injector" or boiler-feed pump or both. Generally both are supplied with large boilers or a battery of boilers, so that one can be used as an auxiliary for the other, or when the other is being repaired. The principle on which the injector acts depends on the fact that steam rushing through a narrow passage creates a partial vacuum and draws the water in with it, imparting a sufficient momentum to the water to overcome the pressure due to the steam in the boiler. The water is passed into the boiler through a pipe supplied with a check valve and shut-off valve. The check valve opens towards the boiler by the water pressure, but as soon as the steam pressure is greater than the water pressure the valve shuts, thus stopping the steam from escaping, or the water from returning. Fig. 14 shows an outline of a common flap-check valve. The shut-off valve is placed between the check valve and the boiler, so that in the case of break-down or the check needing repair the system can be completely shut off from boiler pressure.

The action of feeding water into a boiler tends to lower the temperature of the water already in the boiler, and thus cause an extravagant use of fuel to keep the pressure normal on account of the time it takes to raise the temperature of the feed to the temperature of the water in the boiler. Thus it will be seen that rapid or intermittent injection of feed water is not

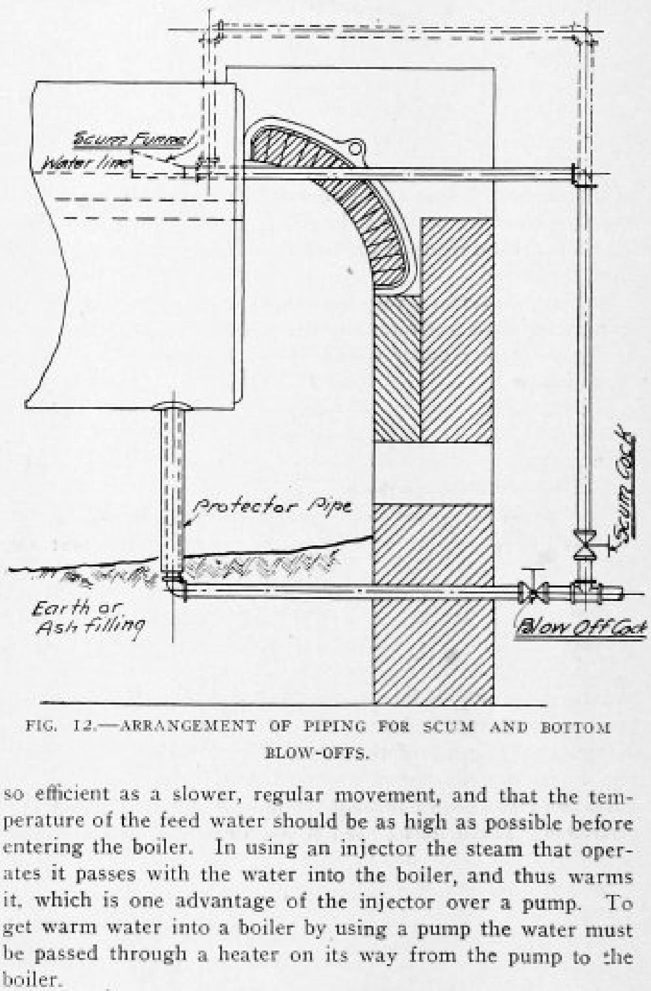


FIG. 12.—ARRANGEMENT OF PIPING FOR SCUM AND BOTTOM BLOW-OFFS.

so efficient as a slower, regular movement, and that the temperature of the feed water should be as high as possible before entering the boiler. In using an injector the steam that operates it passes with the water into the boiler, and thus warms it, which is one advantage of the injector over a pump. To get warm water into a boiler by using a pump the water must be passed through a heater on its way from the pump to the boiler.

The Feed Pipe.

The feed water should not enter the boiler at the bottom, as this tends to increase the amount of "dead water" at that point. The best place on a multi-tubular boiler, such as the one we are considering, is near the back end, about 4 or 5 inches below the water line. If it enters above the water line the steam, being quicker in action than the water in the boiler, will start back quicker after the momentum of the incoming water is lessened, and will cause the check valve to close violently, or in engine room parlance, "will pound the checks to pieces in no time."

To aid the water in the boiler in raising the temperature of the feed, the feed water should be dispersed inside the boiler in as small quantities as possible, and to accomplish this some makers run the feed-water pipe a considerable distance into the boiler, and have the end connected to a branch full of small perforations, the aggregate area of which should be at least twice that of the feed pipe, to allow a considerable margin against some of them becoming clogged up.

Another way is to lead the feed into a box having a perforated cover (below the water line), which may be removed from time to time and cleaned. This is probably the best way, as the box acts as a "catch all" for sediment entering the boiler with the feed water.

The Feed-Water Pump.

As the feed pump is not a direct connection of the boiler (although an important adjunct to the boiler room), I will

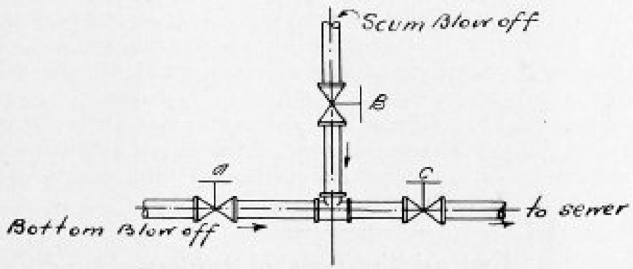


FIG. 13.—ARRANGEMENT OF VALVES IN BLOW-OFF PIPING.

merely give a few of the principal features, such as size, speed, etc.

The size of the plunger of a boiler-feed pump may be approximately determined by the following formula:

$A = E \times .002.$

Where A = Area of plunger in inches.

E = Evaporative capacity of the boiler in pounds of water per hour.

The length of stroke should be from one to one-half times the diameter of the plunger.

The speed of the plunger should never exceed 100 feet per minute, from 50 to 60 feet per minute being the best rate, although pumps are frequently run at higher speeds with good results. The slower the speed the greater the efficiency and the less the wear and tear on the pump valves. As pumps will pump warm water only with great difficulty, owing to air troubles, etc., the water, if warm, should enter the pump chamber by gravity, so that the pump will only have to force the water and not lift it.

The indicated horsepower required to work a feed pump may be determined by the use of the formula:

$$I.\ H.\ P. = \frac{W \times 2 \times H}{33{,}000 \times 60 \times .5}$$

Where

$I.\ H.\ P.$ = Indicated horsepower.

W = Weight of feed water in pounds per hour.

H = Head of water in feet.

NOTE.—The value of H may be found by multiplying the pressure against which the pump must work by 2.31.

THE WATER GAGE AND TEST COCKS.

Now, we have seen that it is very important that the water

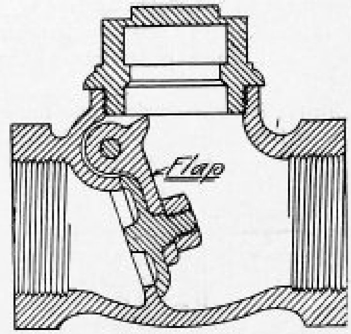


FIG. 14.—DETAILS OF CHECK VALVE.

level in a boiler should be kept constant, so we must have some means of ascertaining the position of this level at all times, and this we have in the water column, gage glass, test cocks, etc.

Fig. 15 shows the position of the water column and its connections on the boiler. The gage glass is connected between two gage cocks, which should be made of good, tough metal, such as brass, bronze or gunmetal, as inferior metals become brittle with the heat. The passages for the water to and from the water column should be ample, seldom, if ever, as small as ¾ inch diameter. The glass is usually from 10 to 12 inches long, and so placed that when the water is just showing in the glass its level is 3 to 4 inches above the top of the tubes. The normal level is generally at the center of the glass. The bottom gage cock should be furnished with a valve so that it may be opened and steam blown through to clean the system. Both gage cocks should be made so that in case the glass breaks the glass passage can be shut off from the column. In a case like this there must be some way of ascertaining the water level while the glass is out of commission. This is managed by means of try cocks or test cocks. These should be at least three in number, the top one being placed about an inch above the top of the gage glass, one an inch below and the third midway between the other two. On account of the

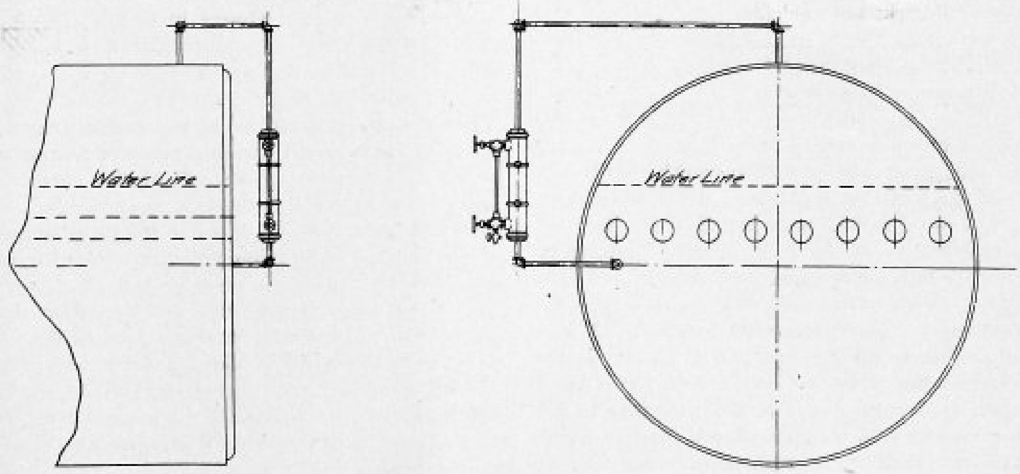


FIG. 15.—LOCATION OF WATER COLUMN AND CONNECTIONS.

liberal expansion of the glass the glands of its stuffing boxes should be at least 1/16 inch greater in diameter than the glass.

THE STEAM GAGE.

To ascertain the pressure of the steam in the boiler we have the steam gage. This is placed either in direct connection with the boiler (the best way) or on top of the water column. There are two principles employed in the steam gage. One is where the movement of the index finger on the dial is derived from the movement of an elastic corrugated plate, caused by the pressure of the steam against it. The other is where this movement is derived from the movement of a bent, flattened tube of metal which is straightened under internal steam pressure.

The latter principle is the Bourdon, and the one most generally used, as it is both simple and reliable. If a tube thus flattened be closed at one end and bent in the form of the

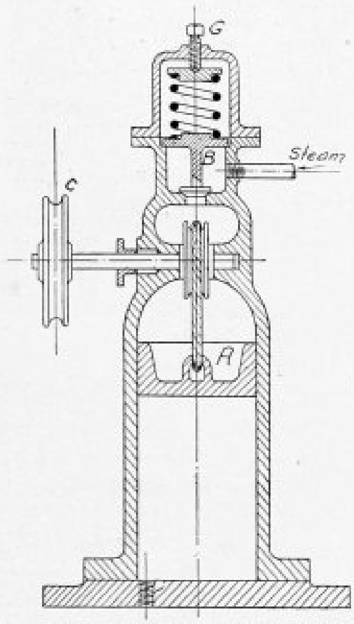


FIG. 16.—COMMON FORM OF DAMPER REGULATOR.

letter U, the application of pressure internally tends to change the shape of the tube to a circular section, which change can only be effected by the partial straightening of the tube, and it is this tendency to unbend that is made use of in the Bourdon pressure gage. One end of the flattened tube is connected to the steam or pressure inlet of the gage and the free end (the closed end), which is allowed to move with the internal pressure, is connected to a lever, on the other end of which is a toothed segment. This segment gears into a pinion on the spindle which carries the pointer. To prevent steam from entering the gage and causing injury by heat, the pipe to the gage is usually furnished with a siphon-shaped bend in which the steam condenses, furnishing a cushion of water against which the steam acts but which prevents the steam entering the gage proper.

HIGH AND LOW-WATER ALARMS.

We have seen what precautions are taken against the change in the water level, but sometimes the engineer or fireman may become lax or forget to keep an eye on the gages, water column, etc. To prevent accidents occurring through this negligence there is sometimes furnished what is called a "water alarm," both for high and low water.

One of the principles on which these operate is that a large hollow ball suspended on the water in the water column is connected by levers to a whistle, electric bell or similar alarm, so that when the ball rises or falls to the danger zone the alarm is sounded to acquaint the negligent fireman of the fact. These alarms are also connected to the steam valve of the feed pump, so that when the ball rises above a certain point the pump is shut off, and when it approaches low water the pump is put into action again.

THE DAMPER REGULATOR.

To automatically regulate the boiler pressure we have the damper regulator, which regulates the heat of the fire. One style of damper regulator is shown in Fig. 16. The valve chamber *B* is connected to the boiler. The spring is adjusted so that it just counteracts the normal pressure on the valve. When this pressure is exceeded the valve lifts, steam is admitted into the cylinder, presses down the piston, thereby rotating the shaft and closing the damper. As the steam pressure falls the damper is brought back to its original position by means of a counterbalance weight on the end of the damper lever.

There are many different types of patent regulators on the market. Nearly all work on much the same principle as has been briefly outlined above, and may be depended upon to do their work effectually.

Hydrostatic Tests of Boilers.

BY T. W. LOWE.

The writer has had little experience with cold-water testing worth relating, and is strongly in favor of hot water in preference to cold-water testing as being the nearest to the working conditions yet provided; and as the material with which we construct a boiler becomes stronger up to about 600 degrees temperature, the hot water test is not so liable to develop an injury to the boiler, and leaks or fractures are less liable to pass undiscovered.

Cold-water testing results in an unusual contraction and is particularly objectionable when the water is cooler than the boiler and atmosphere, as it may result in unnecessary harm as well as render the conditions very uncomfortable for the inspector who should always insist on a tight boiler, or it would be his duty to suspect that it was improperly constructed, should he find seams squirting without being able to satisfy himself as to the cause.

Before subjecting any boiler to excess pressure the factor of safety and authorized working pressure should first be determined. The writer favors 1/6 of the tensile and bursting pressure of a boiler as the safe working load, and considers that new boilers should be subjected to a "proof test" of 1/3 of the tensile and bursting pressure. Each succeeding year it should receive an excess pressure test of 25 percent above its authorized working pressure, and the latter should be considered for reduction at intervals of time not exceeding five years according to its service, condition and pressure, instead of setting various time periods between excess pressure testing; and I do not recommend any specific reduction of pressure at any given age, as I consider the inspector's report should govern.

The internal and external inspections every five years should be very complete, and plates which are affected by decay of any kind, should have a portion drilled out to accurately determine the percent of deterioration, and thus regulate the authorized working pressure to suit the factor of safety adopted.

As will be observed from my remarks in paragraph two, I do not favor any discrimination being given boilers at various ages, and recommend an "excess pressure test" annually for all ages.

It has been my experience to discover numerous defects when testing boilers to excess pressure with hot water, and I will explain a few by the following remarks:

First. The calking on a locomotive boiler, double riveted in the girth seams, could not be made tight at the bottom of the middle course, so it was decided to remove a rivet for inspection of the internal lap, and on discovering the plate section fractured between the rivets it was decided to remove the tubes and get a complete inspection, after which the crack was discovered to be three feet long, thus illustrating the benefit derived from excess testing; as this was a running locomotive and the fracture was hidden, the leak was exposed by the test and subsequent inspection provided a suitable repair before the engine again resumed service.

Second. The throat sheet on a locomotive boiler fractured under excess pressure from the ogee extending almost to the foundation ring. On removal of the defective plate it was discovered that the internal inspection which was made prior to the test could not have exposed the defect as it was a new fracture about two feet long.

Third. Several longitudinal seams have also failed under excess pressure testing, and in all cases coming under my observation there was a partial fracture of the plate prior to the test, which was hidden by other sections of plate covering them; and it is unlikely that any better means could have been employed to expose the defect than excess pressure testing, and it is my opinion that previous excess pressure tests had nothing to do with the development of these or other fractures, but I do consider that unequal expansion and contraction had; and we are likely to have that evil as long as we build boilers, and it will be a very destructive boiler that does not respond to fluctuating temperatures and pressures.

Fourth. During excess pressure testing of locomotive boilers we invariably find a larger number of broken stay-bolts than at any other time, due to the excess pressure separating the partially fractured ones. It has also been a decided advantage to give every locomotive coming in to the general repair shops (and on which there is no heavy boiler work expected) an excess pressure test, as all manner of staying is proved to that extent.

The Effect of Scale on the Transmission of Heat Through Locomotive Boiler Tubes.

The engineering experiment station of the University of Illinois has just issued Bulletin No. 11, "The Effect of Scale on the Transmission of Heat Through Locomotive Boiler Tubes," by Edward C. Schmidt, M. E., and John M. Snodgrass, B. S. This bulletin describes a series of experiments begun in 1900 by the railway engineering department of the University of Illinois to determine the relation of the heat loss due to the thickness of the scale. The experiments comprise tests on single tubes as well as tests of the entire locomotive boiler.

The results of all the tests, plotted with reference to scale thickness, show great divergence in the heat loss, which is ascribed to differences in scale structure. The bulletin is of interest to all who have to do with the operation of steam boilers in localities where pure feed-water is not available. The conclusions derived from the tests are summarized as follows:

1. That for scale of thicknesses up to 1/8 inch the heat loss may vary in individual cases from insignificant amounts to as much as 10 or 12 percent.

2. That the heat loss does increase with thickness in an undetermined ratio.

3. That the mechanical structure of the scale is of as much or more importance than the thickness in producing this loss.

4. That chemical composition, except in so far as it affects the structure of the scale, has no direct influence on heat transmission.

L. P. BRECKENRIDGE.

Kent's Table for the Size of Chimneys for a given Horsepower of Boilers.

This table was compiled by Mr. William Kent from the formula $H. P. = 3.33\ (A - .6\sqrt{A})\ \sqrt{H}$, upon the assumption that 5 pounds of coal are consumed per horsepower. (See page 231, August, 1907.)

Diameter in Inches.	Area A in Sq. Ft.	Effective Area $E = A - .6\sqrt{A}$ Sq. Ft.	Height of Stack in Feet.													
			50	60	70	80	90	100	110	125	150	175	200	225	250	300
			Commercial Horsepower.													
18	1.77	.97	23	25	27	29										
21	2.41	1.47	35	38	41	44										
24	3.14	2.08	49	54	58	62	66									
27	3.98	2.78	65	72	78	83	88									
30	4.91	3.58	84	92	100	107	113	119								
33	5.94	4.48	....	115	125	133	141	149	156							
36	7.07	5.47	....	141	152	163	173	182	191	204						
39	8.30	6.57	....	....	183	196	208	219	229	245	268					
42	9.62	7.76	....	....	216	231	245	258	271	289	316	342				
48	12.57	10.44	....	....	....	311	330	348	365	389	426	460	492			
54	15.90	13.51	....	....	....	....	427	449	472	503	551	595	636	675		
60	19.64	16.98	....	....	....	....	536	565	593	632	692	748	800	848	894	
66	23.76	20.83	....	....	....	....	....	694	728	776	849	918	981	1,040	1,097	1,201
72	28.27	25.08	....	....	....	....	....	835	876	934	1,023	1,105	1,181	1,253	1,320	1,447
78	33.18	29.73	....	....	....	....	....	....	1,038	1,107	1,212	1,310	1,400	1,485	1,565	1,715
84	38.48	34.76	....	....	....	....	....	....	1,214	1,294	1,418	1,531	1,637	1,736	1,830	2,005
90	44.18	40.19	....	....	....	....	....	....	.....	1,496	1,639	1,770	1,893	2,008	2,116	2,318
96	50.27	46.01	....	....	....	....	....	....	.....	1,712	1,876	2,027	2,167	2,298	2,423	2,654
102	56.75	52.23	....	....	....	....	....	....	.....	1,944	2,130	2,300	2,459	2,609	2,750	3,012
108	63.62	58.83	....	....	....	....	....	....	.....	2,090	2,399	2,592	2,771	2,939	3,098	3,393
114	70.88	65.83	....	....	....	....	....	....	.....	.....	2,685	2,900	3,100	3,288	3,466	3,797
120	78.54	73.22	....	....	....	....	....	....	.....	.....	2,986	3,226	3,448	3,657	3,855	4,223
132	95.03	89.18	....	....	....	....	....	....	.....	.....	3,637	3,929	4,200	4,455	4,696	5,144
144	113.10	106.72	....	....	....	....	....	....	.....	.....	4,352	4,701	5,026	5,331	5,618	6,155
156	132.73	125.82	....	....	....	....	....	....	.....	.....	5,133	5,540	5,924	6,285	6,624	7,240
192	201.06	192.55	....	....	....	....	....	....	.....	.....	7,855	8,483	9,066	9,618	10,137	11,090

Boiler Furnaces and Combustion.

Perhaps some figures obtained with Dutch-oven furnaces burning Illinois and Iowa coal may be of interest. In December last we conducted a six-days' test at the Stratford Hotel, for A. J. Saxe. Each day a different coal was burned, and on two of the tests averages of 15.2 and 14.8 percent of CO_2 were obtained. I mention percent of CO_2 obtained first, as this is the proper indicator, so to speak, of furnace performance. The evaporation will depend on the efficiency of the boiler and the heat value of the fuel used. In the above cases the coal was washed screenings, having a value of 10650 and 10850 British thermal units. An evaporation of 7.85 pounds of water from and at 212° per pound of screenings was obtained, with an efficiency of 69 + percent. The plant consists of two 300-H. P. water-tube boilers with Murphy furnaces.

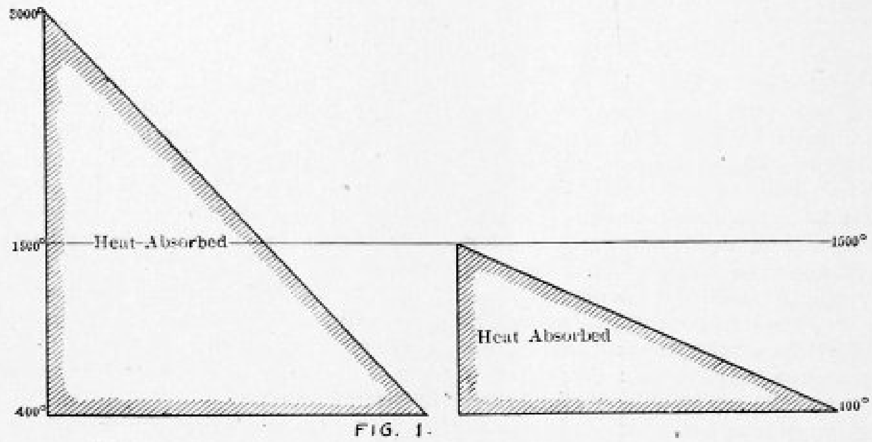


FIG. 1.—GRAPHIC REPRESENTATION OF ABSORPTION OF HEAT.

At Cedar Rapids we installed some return tubular boilers 72 inches by 20 feet, set 5 feet above the grate line with Dutch-oven furnaces in front of each, having 33 square feet of grate surface and 1,600 square feet of heating surface. Tests in June and July, 1905, burning Iowa slack, gave samples of CO_2 taken soon after a charge of coal was thrown in the furnace of from 12 to 14 percent down to 8 percent just before firing a new charge. An evaporation test gave as high as 6.2 pounds of water evaporated from and at 212°; the slack used was of the following composition: Moisture, 16 percent; volatile, 28 percent; free carbon, 38 percent; ash, 18 percent.

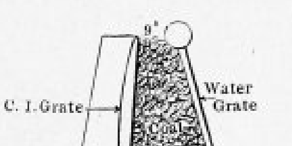


FIG. 2.—EXPERIMENTAL TYPE OF FURNACE.

On test we had 24 percent of refuse. This is very poor fuel. On a basis of combustible the evaporation would be 9.7 pounds. This is higher than any results I have seen reported thus far for Iowa slack. I am coming to believe the "rat-hole" in the average plant in this section of the country is the boiler furnace, and one of the mistakes most frequently made is in the amount of coal burned per square foot of grate surface. Another mistake is setting the boiler close to the grates; and lastly, putting grates under bare tubes or shell, giving too low furnace temperature. What I shall have to say is mostly from personal experience and, owing to the limited number of coals tested, may not be correct for the soft coal territory at large. First, regarding the amount of coal burned per square foot of grate surface for natural draft, I am inclined to think that 25 to 27 pounds of screenings per square foot of grate surface will give the best results. This is 10 to 11 pounds of fixed carbon per square foot of grate surface. As screenings average about 40 percent of fixed carbon, burning this amount under a fire-brick arch with about 0.15 to 0.18 inch of draft at the furnace will give 12 to 15 percent of CO_2, samples taken soon after firing, and if the ash-pit doors are open but 2½ to 3 inches a heavy surplus of air cannot go through the grates when fires are burned down.

At the Stratford Hotel we burned 27 pounds of screenings per square foot of grate surface and obtained an average of 15.2 percent of CO_2, with a furnace draft of 0.17 inch.

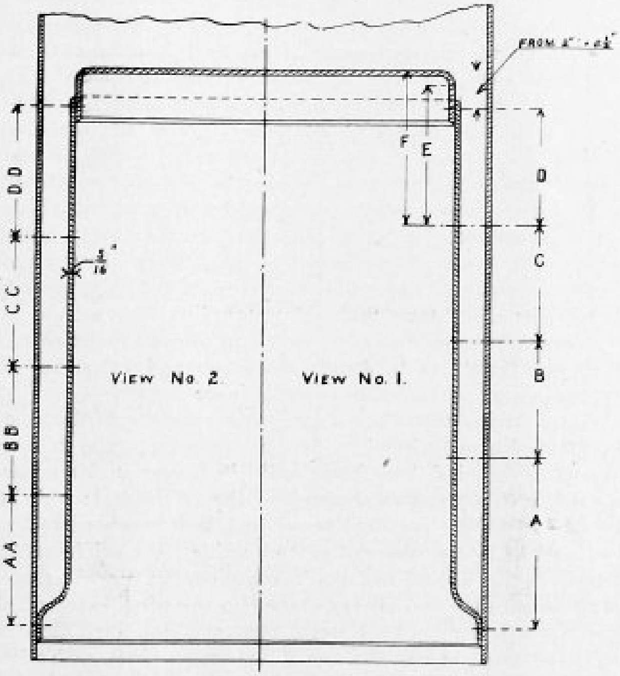
At Cedar Rapids, Ia., with a chain grate under a fire-brick arch its entire length, we burned the same amount with 0.12 inch of draft and 14 percent CO_2, average, frequent samples showing 15 to 16 percent. These various tests with Illinois and Iowa coals seem to point to 25 to 27 pounds of screenings as the minimum quantity to be burned to obtain good results so far as combustion is concerned. The economic results will of course depend on the rate of driving of the boiler and its condition. All in all, it is a simple proposition of high furnace temperature and low uptake temperature, as graphically illustrated in Fig. 1. I have just been reading a paper by Jay M. Whitham on "Tests of Stokers," in which he finds the performance of the Wilkinson stoker improved by increasing the air space from 11 to 26 percent; steam jets were used to blow air through hollow grate bars. He burned anthracite coal. As an illustration of how misleading many experiments with Eastern coals are when applied to Western coals, I will mention a test made three years ago at Cedar Rapids, with a new type of furnace that was in an experimental stage, built as shown in Fig. 2, fire 24 inches thick at the bottom and 9 inches at the top; air pressure, ½ inch; area of openings in cast-iron grates, 4 percent. With this small area for air, this furnace gave 17.4 percent CO_2 for two hours. The furnace was not a success with Iowa coal for the reason that the coal contained so large a percentage of refuse coal and sulphur. It would fuse into a solid mass, and after about three hours' run would have to be closed down and cooled, and it would take the next day to remove it. The point I wish to call special attention to is the small area of air space to give practically perfect combustion when burning Western coals. It seems to me this would be a very interesting question to follow up; namely, proper amount of coal per square foot of grate surface and air space when forced draft is used; also the importance of moderate draft for best economy.

Chicago, Ill. R. B. HOLBROOK, in *Power*.

Staying the Fire Boxes of Vertical Boilers.

BY B. F. THROCKMORTON.

There are in use today, chiefly in connection with hoisting engines, a vast number of vertical boilers built with circular fire boxes. There seems to be a quite common impression that since these fire boxes are circular, and subjected to external pressure, they require practically no staying. While it is true that round furnaces subjected to external pressure will go without stays, it does not follow that any pressure desired can be used. The thickness of the plates and the diameter of



METHODS OF SPACING STAY-BOLTS IN VERTICAL BOILERS.

the furnace have an important bearing on the allowable pressure. In vertical boilers the furnace sheet is of light material in order to permit easy transmission of heat for rapid generation of steam. This thin plate of course will not stand very much pressure; it is, therefore, necessary to figure on staying the furnace sheet, as if it were a flat surface, but since the furnace is round, and capable of resisting some pressure, many have the impression that the necessary stays should be spaced so as to make up the deficiency between the pressure sought and the pressure allowable on the furnace without stays. This is a wrong conception as the strength of the furnace without stays cannot be taken into consideration.

In looking over a number of boilers, I have noticed that the stay-bolts are placed as in view No. 1, the distance between the stays, represented by the letter "A," being about one-third more than *B* and *C*. While this is customary in some boilers, provision is always made to have different sizes of bolts for different spaces. Of course the strength of the plate must be kept in mind, so that it will not be weaker than the bolts.

Assuming that the plate is 5-16 inch and the stays ⅞ inch, threaded twelve threads per inch, U. S. standard (diameter at root of thread being .76675 inch) and the allowable stress per square inch of area, 6,000 pounds, we have

$$6{,}000 \times (.76675)^2 \times .7854 = 2{,}760 \text{ pounds.}$$

This is the allowable strength of the staybolt. The pitch will depend upon the pressure. Assuming 100 pounds as the working pressure, we have $2{,}760 \div 100 = 27.6$ square inches, area to be supported by one stay. The pitch will, therefore, be the square root of $27.6 = 5.25$ inches. Using the U. S. rule for the strength of flat plates with the constant 112, we have for the strength of 5-16 inch plate, stays 5¼ inches pitch,

$$\frac{112 \times 25}{27.6} = 101 \text{ pounds.}$$

Therefore, with 100 pounds steam pressure, the maximum pitch is 5¼ inches, and the plate, according to the U. S. rule, is slightly stronger than the stay.

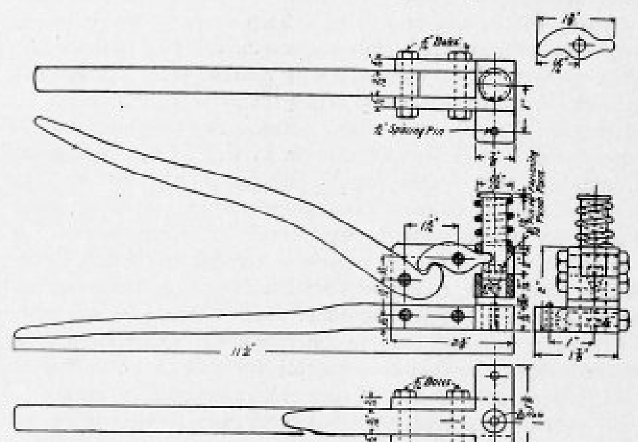
In view No. 1, the stays are laid off with the pitch of the first row greater than the distances *B*, *C* and *D*. Owing to the flanged sheet, it is the general custom to make this pitch somewhat greater than the others, so that stay will not be near enough the flange to be a hindrance in washing the mud from the boiler. As the strength of the plate must be figured from the points at which it is secured, the pitch, *A*, must be taken as the distance from the rivet line to the first stay. The pitch of the top row of stays may be taken from one of three points, as shown at *D*, *E* and *F*. As the gage line on the flange of the fire box head is generally from 2 to 2½ inches from the top of the head, according to the size of the plates and rivets, this is not a matter of great importance. The writer's practice has been to take the distance *D* as equal to the pitch, making *D*, *B* and *C* equal spaces, and *A* about one-third larger. Of course by making *A* larger, the ratio of the strength of the stay and the plate in this space are different from the ratio of the strength of the stay and the plate in the spaces *B*, *C* and *D*, the plate at these spaces being considerably stronger than the stays.

When the boiler is to carry only a small pressure, making the pitch of the stays large, they may be spaced with equal spaces, as shown in view No. 2.

Small Hand Punch for Sheet Steel.

A small hand punch suitable for punching sheet iron jackets, etc., which can be easily made in any shop is shown in the accompanying illustration. The construction of the punch is simple, with a small number of parts arranged in a manner which makes a practical and satisfactory tool for light work.

The length over all is 11½ inches with a 3/16-inch jaw opening and a plunger arranged to receive punch points of various

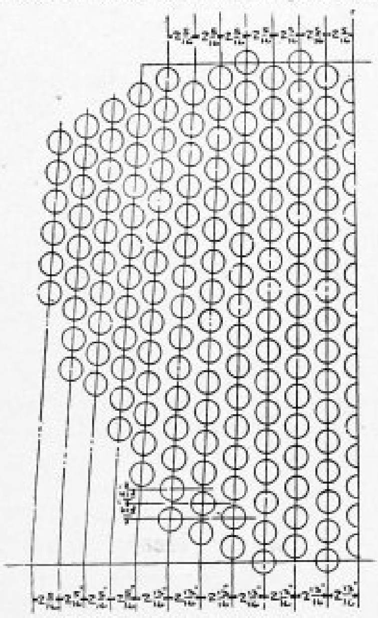


DETAILS OF HAND PUNCH.

sizes. The lower lever is attached firmly to the head casting, and the upper lever is pivoted in connection with a secondary lever which operates the punch plunger. A coiled spring returns the punch to a clearance position when the lever is raised and a 3/16 spacing pin is provided for properly spacing the holes when a series of holes is punched. The punch has been in use in the Covington shops of the Chesapeake & Ohio Railroad for some time and has proved to be a handy and useful appliance.—*Railway Master Mechanic.*

Proper Spacing of Flues in High Pressure Boilers.

The question of the proper spacing of flues for high pressure boilers was taken up at the recent convention of Master Mechanics, at Atlantic City, N. J. A circular of inquiry was sent out by the committee and answers were received from thirty-two members. From the answers received, the majority of the members are in favor of wider bridges than are used at the present time, but no one seems to have made any tests regarding the water circulation between flues or the consumption of fuel, so it is impossible to get data bearing upon



SPECIAL ARRANGEMENT OF LOCOMOTIVE FLUES.

these important points. One of the members recommends very strongly a special arrangement, as shown herewith, an arrangement which has been used successfully for a number of years, but no special tests have been made to determine the efficiency as compared with boilers having the common arrangement of flues, although it is claimed it is a great improvement over the present arrangement in general use. To determine the proper spacing of flues, this subject must be considered from the transportation as well as the mechanical standpoint; that is, the engine failures on account of leaky flues, as well as the cost of maintenance and steaming qualities of an engine, must be considered. The committee is of the opinion that wider bridges, from 7/8 inch to 1 inch, or even wider, should be recommended, but before determining exactly what size bridges should be used it would be advisable to make a series of tests to determine the water circulation between flues, the coal consumption for boilers with different size bridges, as well as the cost of maintenance in regard to flues. The committee started several tests to determine the above question in regard to water circulation between flues and the coal consumption, and to ascertain if the same size bridges could be used in both large and small boilers without interfering with the steaming qualities of the engine, but they were unable to continue the tests so that positive data could be obtained on account of unavoidable interference of business. The width of bridges and the necessary reduction in flue heating surface can be determined only by a series of tests to ascertain how far we can go without detriment to the efficiency of the boiler, both in regard to steaming qualities and coal consumption, and at the same time obtain the best results in flue maintenance.

Fallacy About Boiler Explosions.

An experienced engineer telling to a newspaper reporter notes of narrow escapes from being present at boiler explosions, told of finding a man trying to pump water into a red hot boiler which the engineer concluded would have resulted in a disastrous explosion had the cold water reached the hot plates. We would have excused that man if he had not emphasized the claim that he is an engineer of training and experience.

There is a prevalent belief among people, who ought to know better, that should a steam boiler get hot through shortness of water, and feed-water be suddenly injected upon the hot plates, an explosion is almost certain to follow. The fallacy of this has been repeatedly demonstrated by experiment in the United States, and several years ago the Manchester Steamusers' Association instituted a series of tests to ascertain the effect upon an overheated boiler of the entrance of cold water, which ought to be widely known. Three tests were made, the boiler plates in each case being heated nearly to redness. Water was then introduced. In one case the steam pressure rose within a minute from 6 to 27 pounds, but in the other tests the cold water did not result in increasing the pressure at all. The effect of the sudden change of temperature was to distort the plates and tubes, but no indications of an explosive tendency were found.

In connection with these tests, some experiments described by Mr. Coleman Sellers long ago at a meeting of the Railway Master Mechanics' Association will be of interest, for boilers are liable to act to-day as they did then. He said: "A locomotive, which was condemned and had been ordered to be taken to pieces, was run out on a side track off from Altoona, in the woods, and they determined to try an experiment which they had always desired to see tried, namely, the firing of a boiler until the steam was very high, then blowing it out so as to expose the top of the crown sheet, and allow it to become red hot, and with a large fire engine force water into that engine. They fired it up and retired to a safe distance. They saw the pressure gage go up to 125 pounds; then the lock-up safety valve blew off, showing it was not weighted heavily enough. They had no means to determine, except by guess, and retired a second time thinking they could then go on with the experiment as they intended, but they had hardly gone from the boiler—they were not 5 minutes away from the boiler when the pressure gage hand seemed to run as rapidly as anything could until it reached something near 200 pounds, when the engine blew to atoms. It was full of water, with every condition that would insure safety, except that the pressure was a great deal too great for the strength of the material composing it. No other reason could be given for the explosion.

They then took a second engine and treated it in the same manner, but that one happened to be strong enough to sustain the pressure they desired. They blew the water out, and when the glass gage indicated that it was below the red-hot crown sheet they pumped water into it, and in pumping in it behaved as I had seen it do in other cases. The steam merely went down. Once or twice or three times they repeated it. The boiler was injured by the fire, but it did not explode or do any harm to inject large quantities of cold water into the very much heated boiler.

In other experiments made at the Harrison Boiler works with cast-iron boilers, many gentlemen present, representing a committee of the Franklin Institute, were anxious to see this experiment of a red hot boiler having water suddenly injected into it tried with a cast-iron boiler. They had already fired one of them up to a pressure of 170 pounds. One of these same boilers was fired up to 150 pounds, the blow-off cock was opened, and the whole of the steam discharged. We waited 10 minutes, and heated the furnace so that a stick of wood put against the boiler would immediately become ignited, and we injected the water in. But, instead of making steam, it cooled off the boiler. We waited for steam, blew it off again, and three times we repeated that experiment, and during that whole time I was standing within 5 feet of that boiler, with my hand on it most of the time, and it behaved just exactly as a mass of iron of that size should behave; that is, the water passed into it, merely cooling off the iron and doing nothing else. The experiment was very interesting and was very conclusive that the whole mass of the boiler, if heated red hot, does not contain heat enough to raise the water in the boiler up to the steam point.—*Railway and Locomotive Engineering.*

Explosion From the Boiler of the Steam Drifter Kingfisher, of Granton.

This boiler is of the ordinary cylindrical multitubular marine type. It is about 9 feet 10 inches in diameter, and about 9 feet 7 inches long, being fitted with two furnaces about 3 feet in diameter, connected to a cumbustion chamber common to them both.

The boiler is said to have been removed from the steamship *Sir Francis Head,* on board of which vessel it had been little used. The year of construction, said to be 1895, could not therefore be verified. The boiler was bought by the present owner and fitted on board the *Kingfisher* in April, 1900. At that time bolted patches appear to have been been already fitted at points *A, B* and *C* in the figure. There was also a patch 14 by 10 inches over the shell seam at the bottom of the boiler, and new furnaces appear to have been fitted. In December, 1903, riveted patches appear to have been fitted at *D* and *E* by Messrs. T. & H. Morton & Company, Leith. In April, 1904, the owner had the bolted patch at *B* replaced by a larger one riveted to the boiler, the owner's engineer and boiler maker doing the work. In April, 1905, the bolted patch at *C* was replaced by a larger bolted one. These patches had to be enlarged owing to the corrosion of the plate around the old patches.

The explosion was due to the local wasting of the combustion chamber bottom plate on the fire side until it became so thin that it was unable to withstand the ordinary working pressure. A hole 1½ inches long by 1 inch at the broadest part was formed in the bottom plate of the combustion chamber close to the patch marked *A*. Through this opening the contents of the boiler escaped rapidly into the stokehold. The pressure in the boiler at the time of the explosion was about 75 pounds per square inch.

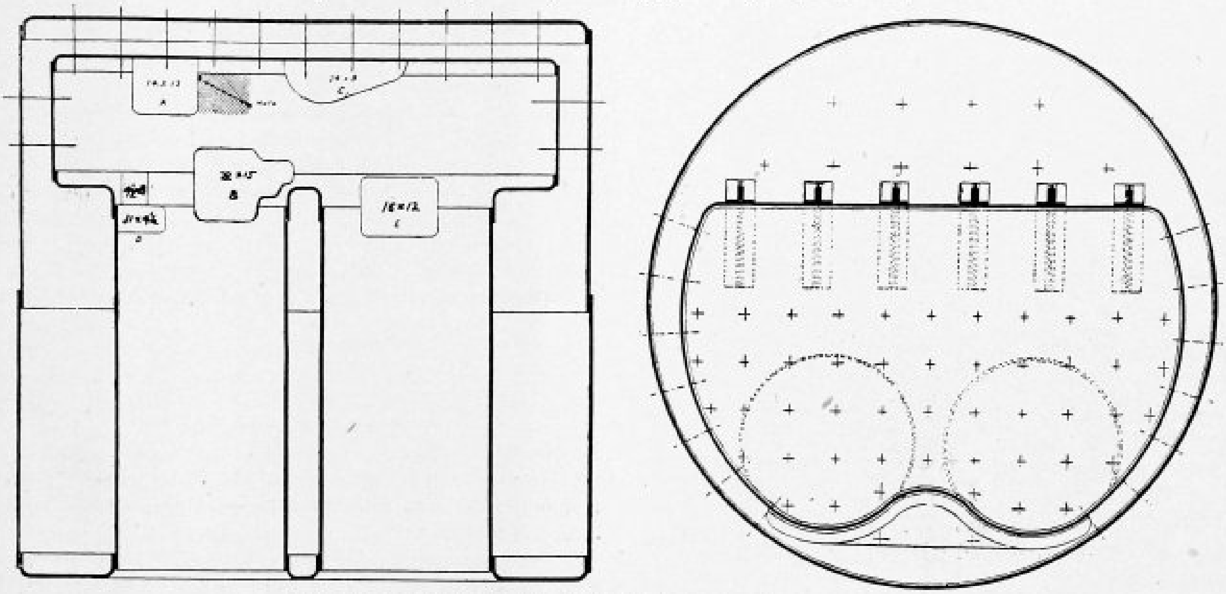


DIAGRAM SHOWING LOCATION OF PATCHES ON BOILER OF KINGFISHER.

Laying Out Elbows by Means of a Table of Natural Tangents.

BY J. M. JONES.

Referring to Fig. 1 the length of the throat or back of the elbow, that is, the distances *a b* or *A B* may be obtained by multiplying the radius or length from the center *C* to the throat

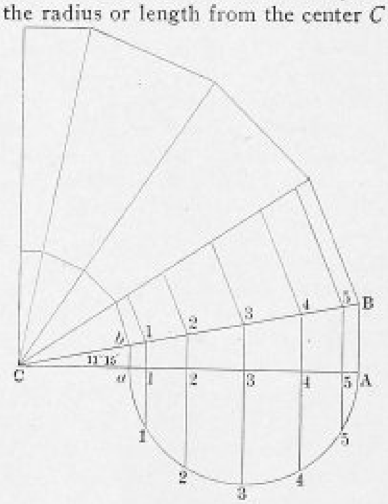


FIG. 1.

a, or to the back *A,* by the natural tangent of the angle *ACB,* as given by the accompanying table. This table gives the angles for a 90-degree elbow made of three, four, five, six, seven and eight courses, respectively, and the corresponding tangent for either the throat or back, the distances being expressed in feet or inches as may be required.

By referring to Fig. 3, which shows the outlines of elbows constructed of from three to eight courses, it will be seen that there is no necessity of drawing a complete elevation of an elbow in order to lay out a pattern of one course. The full length ordinates or projections of large elbows may be ob-

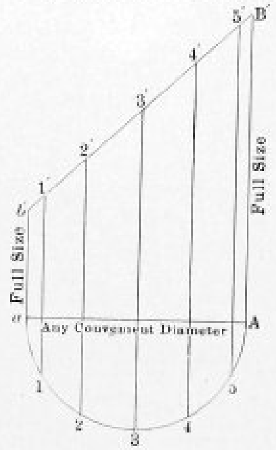


FIG. 2.

tained as shown in Fig. 2. Having obtained the length of the throat *ab* and the back *AB* by the above rule, draw the lines

No. of Pieces.	Angle at Center.	ab = Ca Times.	AB = CA Times.
3	22° 30′	.41421	.41421
4	15°	.26795	.26795
5	11° 15′	.19391	.19391
6	9°	.15838	.15838
7	7° 30′	.13165	.13165
8	6° 25′ 43″	.11268	.11268

ab′ and *AB′* equal in length respectively to the lines *ab* and *AB*. Lay off the line *aA* of any convenient length and draw the line *b′B′*. From the center 3 describe a semi-circle and

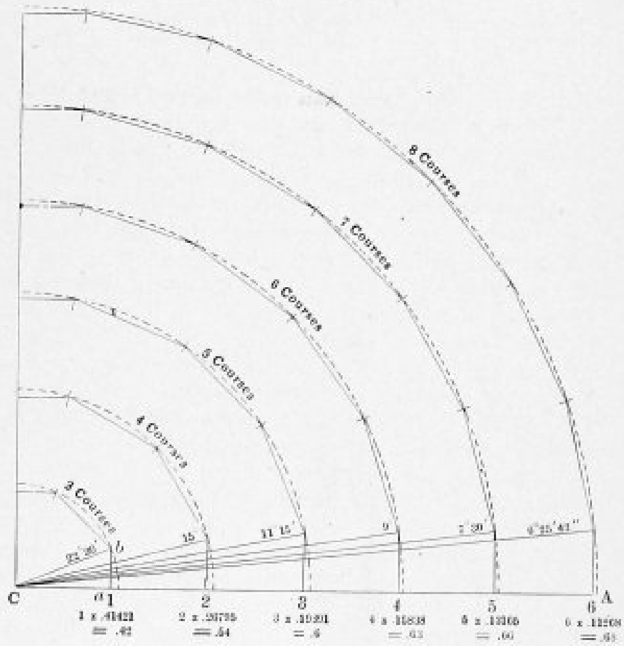


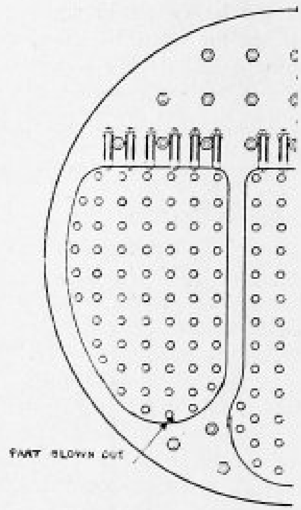
FIG. 3.

divide it into a number of equal parts; from each division erect perpendiculars to *AB*, 1 1′, 2 2′, 3 3′, etc., terminating at the line *b′B′*. Then the lines 1 1′, 2 2′, etc., will be the full-length ordinates for developing the section of an elbow, regardless of the diameter of the elbow.

Explosion From the Main Boiler of the Steamship Pearl.

The steamship *Pearl* is a screw steamer of 691 gross tonnage, and 90 nominal horse-power, employed solely in the coasting trade.

The boiler which formed the subject of this inquiry is of steel, with iron tubes, and is of the ordinary cylindrical multi-

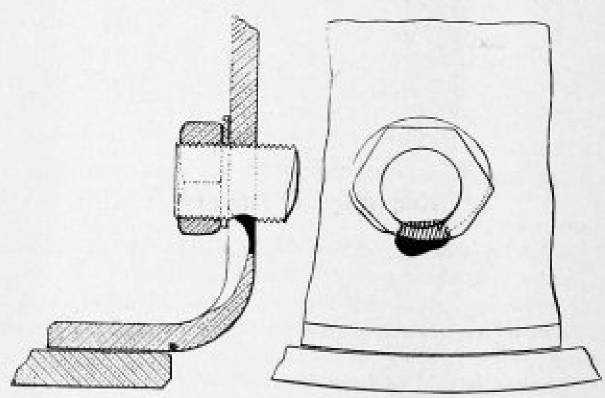


LOCATION OF LEAKING STAY-BOLT.

tubular marine type, single-ended, 14 feet in diameter by 10 feet 6 inches long, with three plain furnaces, each 3 feet 6 inches in diameter.

There is a separate combustion chamber to each furnace, the wrapper and back plates of which are 9-16 inch thick, supported by screwed and nutted stays pitched 8¼ inches apart each way. The boiler is fitted with the usual mountings, including two spring-loaded safety valves adjusted to blow off at a pressure of 160 pounds per square inch.

The engineer surveyor-in-chief states that the explosion in this case was the result of the corrosion of the back plate of



MANNER IN WHICH PLATE CORRODEED.

a combustion chamber, consequent on leakage around one of the stays, whereby the plate was so reduced in thickness that it could not successfully withstand the ordinary working pressure of the boiler, and a small portion was blown out. Although the part effected was very local, it was plainly visible from the inside of the combustion chamber, and, as the wasting action must have been going on for a considerable time, it is somewhat surprising that the defect was not noticed and remedied before the explosion occurred, for one would have thought that the leakage which doubtless existed would have drawn attention to the condition of the plate.—*Page's Weekly*.

The Specific Heat of Fire Brick at High Temperatures.

BY C. FLETCHER HOWE AND CHARLES B. HARRINGTON.

Although the value of the specific heat of fire brick (especially at high temperatures) is necessary in many calculations, nothing had been done to determine it further than to estimate it roughly from the specific heats of the constituents of the brick until the authors took up the subject in 1904, continuing the work in 1906.

The brick (2½ inches by 2½ inches by 3 inches) is uniformly heated in a gas furnace to a high temperature and then quickly transferred to a form of Bunsen's ice calorimeter of suitable shape and dimensions, designed for the purpose. The initial temperatures, ranging from 500 degrees to 1,100 degrees C., and subsequent temperatures are observed by means of a thermo-couple which extends through the bottom of the calorimeter into the center of the brick.

In each experiment the brick is allowed to remain in the calorimeter until a definite temperature at its center is reached, (200 degrees C.) and then quickly removed. The heat given up by the brick in cooling from the initial temperature down to this fixed temperature, expressed in calories, when plotted against "initial temperatures" gives a parabola represented by the equation

$$H = at + bt^2.$$

when H represents the heat in calories, and t, the initial temperature. The values of the constants are found to be,

$$a = 117.7 \text{ and } b = .016.$$

The specific heat is the differential coefficient of H with respect to t, and the values calculated for each interval of 100 degrees are recorded below.

Temperature Range.	Specific Heat.
1100° — 1000°	.281
1000 — 900	.274
900 — 800	.268
800 — 700	.262
700 — 600	.257
600 — 500	.251
500 — 400	.245
400 — 300	.239
300 — 200	.233
200 — 100	.227
100 — 0	.221

—*Journal Worcester Polytechnic Institute.*

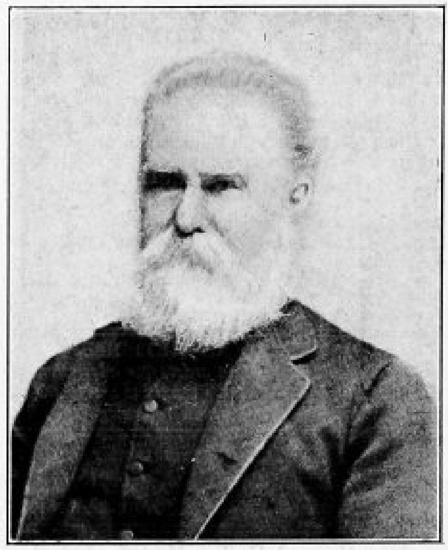
PERSONAL

Mr. J. E. Bossingham, formerly of Manitowac, Wis., has recently accepted a position as superintendent of the Canton Boiler & Engineering Company, Canton, Ohio.

"Compressed Air," formerly published by the Kobbé Company, 108 Fulton street, New York, is now being published by the Compressed Air Magazine Company, Bowling Green building, New York. Mr. W. L. Saunders remains editor of the magazine, but Mr. Hulbert, who was formerly managing editor, has been succeeded by Mr. Frank Richards. Mr. Richards is well known in this field of engineering, as the author of "Compressed Air," the standard text book on this subject. He has long been connected with technical journalism, having been for ten years one of the editors of the "American Machinist." Previous to his work on the "American Machinist" he spent several years in machine manufacturing with the Ingersoll-Sergeant Drill Company and other concerns. Mr. Richards thus brings to his new position a wide and varied experience not only in the particular branch of engineering which deals with compressed air but also in general steam and mechanical engineering.

OBITUARY.

Homer Parmelee, of Chicago, Ill., died at the home of his brother, Justine Parmelee, 1056 West Monroe street, Chicago, on Monday, Aug. 12, aged 89 years. Mr. Parmelee was born in Middlebury, Vt., Dec. 31, 1818, of the good old *Mayflower* stock. He was the oldest of twelve children of Howell Parmelee, of West Troy, N. Y., the inventor of the first successful coal or wood cook stove, known in those early days as Parmelee's Diamond Cook. He was a pattern maker by trade, and was employed for years by Bartlett, Hayward & Company,



HOMER PARMELEE.

of Baltimore, Md., on account of his great genius of invention. Many practical machines used in boiler shops are due to this man's genius. In his eightieth year the necessity of a pipe wrench that would not chew the pipe nor mar the threads brought from his still fertile mind a device very much like the hand itself, and, fortunately, patented by himself as the Parmelee pipe wrench, which he was successful in marketing in Philadelphia, Pa. After five years enjoyment of the fruits of his latest invention he failed in health and came to live with his younger brother, Justine, to whom he transferred the burden of his business affairs, slowly declining until the end. The wrench business will continue—a close corporation, with his brother and nephew in charge—as a living monument to the wealth of his inventive genius.

Word is received of the death on July 11, 1907, of Mr. John M. Smalley, a member of the International Boiler Makers' Association. Mr. Smalley was born in Audrian County, Mo., Nov. 9, 1863. He came to Los Angeles with his parents in January, 1872. At the age of eighteen years he responded to his mechanical ambitions and entered the employ of the Southern Pacific Railroad Company as a machinist's apprentice. Not taking very kindly to the machinist's trade, he was later transferred to the boiler shop and sheet iron department, where he remained until 1887, when he became affiliated with the Lacy Manufacturing Company. Soon after taking up his new duties with this company he was advanced to the position of foreman, and until the time of his death he was recognized by this firm as one of their most honest and conscientious employees. He leaves a widow and son and a host of friends, who will remember his honest, honorable and ambitious life as one worthy of emulation by his fellow workmen.

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - - New York

Christopher St., Finsbury Square, London, E. C.

H. L. ALDRICH, President and Treasurer

S. W. ANNESS, Vice-President
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Branch Offices.
Philadelphia, Pa., Mach'y Dept., The Bourse, S. W. ANNESS.
Boston, Mass., 170 Summer St., S. I. CARPENTER.
Chicago, Ill., 625 Monadnock Building, H. S. Moss.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico........	$1.00	.10
Other countries in Postal Union..........	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

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.

Attention of Boiler Manufacturers.

We are authorized by Col. M. F. Cole, president of the American Boiler Manufacturers' Association of the United States and Canada, to extend through our columns a most cordial invitation to all boiler manufacturers of the United States and Canada to attend the nineteenth annual convention of the above association, which is to be held at the Piedmont Hotel, Atlanta, Ga., Oct. 8, 9 and 10. This we do with the earnest desire that all manufacturers who are in any way connected with the boiler making industry will make a special effort to be present at the convention this year, and devote a few days of their time to furthering the interests of this important industry. Many matters of vital importance pertaining to both the mechanical and financial branches of the business will come up for discussion and action at this time, and a large attendance and a proper show of enthusiasm will do much to accomplish results which will be in keeping with the previous work of the association and which will be of lasting benefit to all concerned. Complaints have been made that at the last few conventions too much attention has been paid to carrying out the elaborate programs of entertainment which have been provided for the members and their guests, and that as a result the business sessions have suffered. Col. Cole is determined that this year nothing shall interfere with the business sessions of the association, and that the major portion of the time shall be spent profitably. This does not mean that nothing will be done to make the manufacturers' visit to Atlanta a pleasant one, as a glance at the program published elsewhere in this issue will show that the time outside of business hours will be fully occupied with excursions and social functions of such character as to insure a good time for all, and especially for the ladies and guests of the association. It seldom happens, for reasons of accessibility, that a Southern city is chosen as the meeting place of an association whose members are so widely scattered, and so the most should be made of this opportunity to enjoy the warm-hearted hospitality of the Southern people.

Superheaters.

The value of superheated steam as a means of increasing the economy of a steam power plant is somewhat uncertain and varies widely with different types of engines. A gain in economy of steam consumption of over 30 percent has been shown in the case of a slow-speed, full-stroke engine, while with a high-speed triple expansion engine with steam jackets, reheaters, etc., the gain may not amount to more than 5 percent, although in the latter case the entire plant is frequently large enough, so that a gain of even a few percent is of much importance. In either case the increase in economy of coal consumption frequently equals that of the steam consumption, although the average increase is probably considerably less. In view of these facts there is bound to be a more or less complete development of superheating apparatus. At present there are two general types of superheaters in use: a separately fired apparatus and one which is combined in the boiler setting. In either case the saturated steam is passed through a coil or series of pipes placed in the path of the hot gases. The prevailing practice in this country appears to be to use the first form of apparatus and to adapt it to standardized forms of boilers and settings. Thus the superheater is regarded by boiler makers as an extra fitting rather than as an integral part of the boiler.

The criticism has been made that boiler makers are loath to disturb their customary and accepted designs of boilers to provide superheating surface. This is absurd. The main difficulty is that the satisfactory superheating boiler is yet to be designed, and meanwhile the best must be made of a poor situation by adapting various superheating devices to existing types of boilers in such a way that the heating surface of the boiler will not be too greatly reduced and at the same time the desired degree of superheat obtained. The usual point in the path of the furnace gases at which the superheater is placed is about midway of the travel of the gases or at a point where they have given up about half of their heat to the boiler. In the case of the Scotch marine boiler the superheating apparatus has frequently been placed in the up-takes, where the gases do not come in contact with it until they have passed entirely through the boiler. Similarly in the locomotive boiler the superheater has been installed in the smoke-box, although in the later case there is some tendency towards utilizing a part of the flue-heating surface of the boiler as superheating surface.

The type of superheater which is installed in the boiler setting has some distinct advantages over the separately fired type, in that no additional space and little additional piping is needed. On the other hand, the degree of superheat is subject to fluctuations corresponding to the changes in the temperature of the furnace gases, caused by the addition of fresh fuel to the fires, a change in the amount of draft or air admitted to the furnaces, etc., and the superheater must be flooded when raising steam.

COMMUNICATIONS.

Lap Joint Boilers from an Operating Engineer's Point of View.

EDITOR THE BOILER MAKER:

The communication which appeared in the May issue of THE BOILER MAKER relative to lap-joint boilers from an insurance engineer's standpoint, interested me greatly; so much so that I would like to express the opinion of an operating engineer on this question.

The advisability of making boilers with butt-joints has been pretty well thrashed out in the technical papers, and nearly all agree that although the lap-joint boiler is not as preferable as one constructed with a butt-joint, nevertheless, it does not preclude it from useful work, or from being operated under fairly safe conditions. In my experience as an engineer I have never had very much trouble with lap-joint boilers, neither have I felt that they were not as safe to operate as any other kind, provided the boiler pressure was kept down within reasonable limits.

The records of the past few years show that there has been a large number of boiler explosions of one kind or another occurring with boilers of types other than the return tubular boiler constructed with longitudinal lap joints, and some of them have been very disastrous. A boiler explosion usually seems to be shrouded in mystery. The boiler is said to be steaming as usual, and at the next moment it and its surroundings are a mass of wreckage. Low water is at first attributed as the cause, but there is usually some one who escapes injury who is in a position to state that the water level was at the second gage only a few seconds before the explosion occurred. When this point has been proved, of course a new reason for the explosion must be found, and then it is that the lap-joint seam comes in for its share of the blame, although the condition of the plate in other sections of the boiler is occasionally declared faulty, even though ten or fifteen years may have elapsed from the time the boiler was first put in use.

A question that has always puzzled some engineers not a little is, why should a boiler be operated for years without any apparent defect and then suddenly explode? Because the manufacturer failed (?) to produce a plate sufficiently solid to withstand a boiler pressure of, say, 80 pounds? If the weakness had developed at the beginning of the service we could reconcile the argument of a faulty plate to the facts of the case, but in many cases which have been brought to notice the facts and assumptions do not agree, from a common sense point of view at least.

Knowing the usage that a boiler receives in the course of ten years' service from practical observation in the boiler room, it is strange that there are not more boiler explosions than there are. It is doubtful if any other apparatus in existence receives more abuse and hard usage than the steam boiler as found in about 90 percent of the steam plants in operation to-day. For instance, a boiler is shipped to a certain firm and is rated as, say, 100 H. P. It is set up in its setting and the proud engineer, who receives about $1.75 per day, is given full charge of the steam plant. If he understood his business he would merely build a small fire on the grates the first day in order that the masonry might be tempered ready for a hotter fire. The next day the fire would be maintained so as to keep the water in the boiler at about 200 degrees heat, and the third day a few pounds of steam would be carried until late in the afternoon, when the steam pressure would be run up to the working pressure and the fires later on banked, when the boiler would be filled with water to the third gage and the boiler cared for for the night.

What is done in altogether too many cases is that as soon as the masons are through with the setting the $1.75-engineer fills the furnace full of rubbish which has accumulated in the fire room and starts a hot fire under the boiler, not neglecting to maintain the draft at its greatest strength. What is the consequence? The boiler is heated up in a very short time, and, of course, unequal strains have been developed which weaken the boiler to a considerable extent. In the course of about 2 hours the boiler has steam on it and the pressure at the operating point. There are several reasons for treating a boiler in this manner. First, the attendant may be ignorant of the danger of forcing a fire under a cold boiler. Second, he may know all about the damage that may be done, but is in a hurry to get home and, therefore, runs the chance of getting up steam without doing any damage. The third reason is that the attendant knows about such things as unequal expansion, but is careless and thinks that there has been more stress put upon the question than it deserves, and so discounts the amount of damage which may be done through bringing a cold boiler up to a heated state with pressure on it. No one will claim that the boiler will have been ruined, or anywhere near it, because of one offense, but a start has been made and a continuance of such practice will bring disastrous results.

If the attendant is at all skeptical as to the results of expansion and contraction he will have his fears allayed when he sees that the boiler has not developed leaks from the rapid heating, and so will be in no wise backward in repeating the performance if necessity seems to demand it. He may deem it a case of necessity to force the fires under a boiler when he had washed it out and finds that the time is extremely short before it will be time to start the plant. Remembering that apparently no damage was done as a result of his first attempt at raising steam in record time, the fires are started again and steam is raised in time to start the machinery and the engineer has redeemed himself. The question which arises before me is, how many times can a boiler be abused in this manner before it begins to show signs of weakening, or before the lap joints will begin to crack where it cannot be detected?

Not only is there a tendency to burn a fire with intensity when getting up steam from a cold boiler, but there is also a danger that the fires will be forced too hard when getting up steam in the morning. For instance, the engineer gets up a little late in the morning, and as he does his own firing about eight months in the year, he must depend upon his own exertions in getting things in operation in the morning. He reaches the boiler room at about 10 minutes of starting-up time, and finds that there is a pressure of about 60 pounds. The fires are hastily raked out and the drafts are opened wide, so that the steam may rise as much as possible before the engine is started. In order to assist matters the fires are barred and an extra amount of cold air permitted to enter the furnace. Between acts the engine is made ready and the whistle blown. The engine then receives its load and the engineer's attention for the next half hour is given to getting up steam to the usual operating point, say, 90 pounds. In order to maintain the steam pressure, let alone gain, it is necessary to fire hard and to force the fires to the greatest extent possible. Now, this may not have any great effect as regards expansion and contraction, as the boiler was hot in the beginning, but with the engine laboring under a low steam pressure and the boiler working to its utmost to supply the steam, that condition known as "breathing" takes place, which is undoubtedly the cause of the cracked lap-joint seam. Just how long this can continue is not easily answered. It depends greatly on how often the fires are forced in the manner described and how great a load the engine is carrying. There is this to take into serious account, however, the boiler cannot withstand such treatment indefinitely, and sooner or later will develop defects which will either be discovered before a serious accident has occurred or the defect will result in a boiler explosion of more or less severity.

While there have been many cases where boiler explosions have been caused directly by faulty work and material furnished by the boiler manufacturers, it appears to me from my own personal observation that most boiler explosions are brought about by the abuse received at the hands of the men having the boilers in charge. The wonder is that there are not more boiler explosions than there are. E. PRICE.

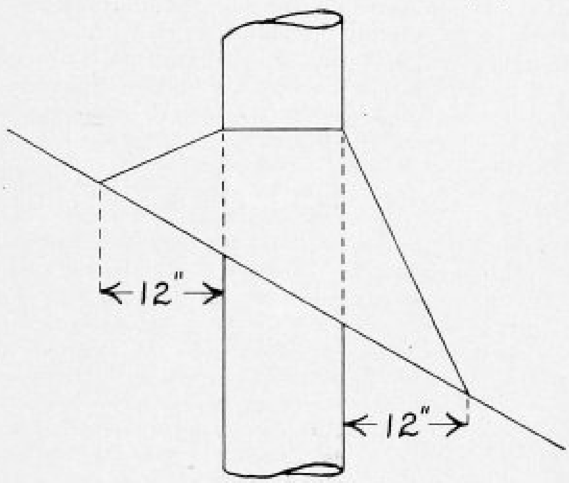
QUERIES AND ANSWERS.

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.—Will some of the readers of THE BOILER MAKER please show how to lay out a fire-box and the shell sheets from the back leg to the front leg of any type of locomotive boiler? CENTER PUNCH.

Q.—An argument having come up in our shop regarding the development of a collar for a smoke-stack which passes through a pitched roof, I would be pleased to have you advise me, through your Queries and Answers column, if this collar can be developed by the method of radial lines or by any other method shorter than triangulation. T. G. C.

A.—Since all the points on the line of intersection of the collar and roof shown in the sketch are the same perpendicular



SKETCH OF COLLAR FOR STACK PASSING THROUGH PITCHED ROOF.

distance (12 inches) from the stack, and at the same time lie in a plane which makes an angle other than 90 degrees with the stack, it will be seen that the collar does not have a regular taper. Where the method of radial lines is used all elements or lines drawn radially upon the surface must intersect at a common point called the apex, and as this can only happen when the surface has a regular taper, the method of radial lines cannot be used in this case. There is no method shorter than triangulation by which this problem can be solved.

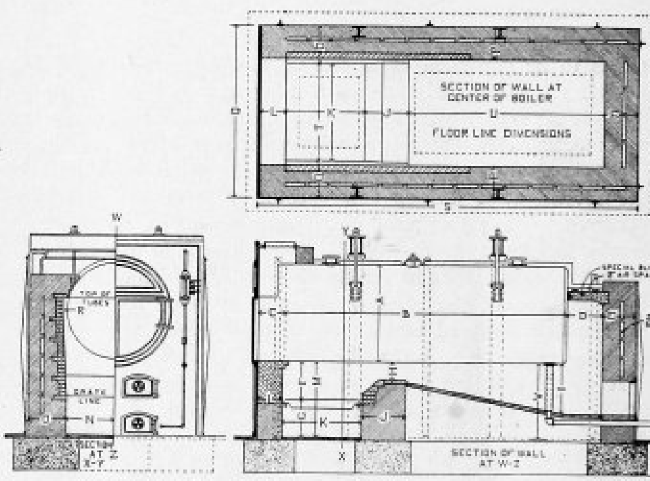
Q.—How is the steam space of a boiler calculated, and how do the number of revolutions per minute of the engine enter into the calculations? NIGHT ENGINEER.

A.—The steam space in a cylindrical tubular boiler is frequently made equal to one-third of the volume of the boiler shell. A more logical way, however, is to proportion the steam space to the rate of steam consumption by the engine. Thus the ratio of the volume of the steam space to the volume of the high-pressure cylinder of a multiple-expansion engine varies from 50 : 1 to 140 : 1.

The capacity of the steam space is frequently made equal to the volume of steam consumed by the engine in 20 seconds, that is, assuming a mean value for the volume of the head end and crank end of the high-pressure cylinder at cut-off, the steam space is made equal to two times mean volume of high-pressure cylinder at cut-off times the number of revolutions per minute times twenty-sixtieths, or one-third.

Q.—What is the best way to set a 60-inch by 16-foot horizontal tubular boiler? Please give the dimensions of the side and bridge walls, etc. TRAMS.

A.—The usual form of setting for a tubular boiler is shown in the accompanying sketch. The parts of the walls which are exposed to the flames should be of fire brick, and the rest of hard well-burned brick. The side and back walls should have an air space about 2 inches wide in the center to prevent the radiation of heat. The dimensions for such a setting for a 60-inch by 16-foot boiler should be approximately as follows: The area of the grate, which is a factor determined by the horsepower of the boiler, kind of coal used and draft required, must be determined for each specific case. The size of the grate will determine the position of the bridge wall. The area between the top of the bridge wall and the boiler should be approximately one-seventh of the grate area.



ORDINARY FORM OF SETTING FOR A TUBULAR BOILER.

The height of the wall is usually made such that the distance from the top of the wall to the bottom of the boiler will be between 8 and 12 inches. The thickness of the side wall (*P*) and the back walls (*E*) is 23½ inches. The distancce from the back of the boiler to the back wall (*D*) is 24 inches. The arch from the back wall to the boiler and also from the side walls to the boiler should be just above the top row of tubes. The width of the bridge wall (*J*) is 30 inches. The height from the foundation to the bottom of boiler (*M*) is 50 inches. The distance from the side wall to the outside of the boiler (*R*) should be about 3 inches.

A good foundation for the setting is a solid bed of concrete, about 24 inches thick, although on firm soil a foundation may be conveniently made of large rough stone work about 3 feet wide under the side, middle and end walls only. The side walls are braced by three sets of buck-staves with through rods under the paving and over the top of the boiler. The method of suspending a boiler from I-beams costs a little more than when the boiler is supported by wall brackets which rest upon the brick work. It is a practice, however, which pays in the long run, as boiler walls, especially when the boiler is supported from wall brackets, will settle more or less, and it is safe to say that this settling causes undue strain by reason of the boiler resting on two diagonal corners. When the boiler is supended from two overhead I-beams, the strain can be more evenly distributed.

Q.—Please give me a complete discussion of the shearing and crushing of both plate and rivet in a single riveted lap joint of ⅜-inch plate with 13-16-inch rivet holes, spaced 2 inches between centers. It is to be assumed that the failure is not to occur by shearing the rivets or breaking the net section of the plate, but either that the lap is to shear out from the center of the rivet hole to the edge of the sheet, or that the plate or rivet is to fail by crushing. Tensile strength of plate 60,000 pounds per square inch; shearing strength of rivets 42,000 pounds per square inch. FAILURE.

A.—If T = the thickness of the plate,
D = diameter of the rivet holes,
P = pitch, or distance between centers of rivets,
L = lap or distance from center of rivet to edge of plate,
F_c = crushing strength of steel,
F_s = shearing strength of steel,
F_t = tensile strength of steel.

Then the resistance of the joint to crushing either the plate or rivet $= F_c \times T \times D$; the resistance of the joint to shearing the plate from the center of the rivet to the edge $= 2 \times F_s \times T \times L$, and the resistance of the joint to shearing the

$$\text{rivet} = \frac{3.1416\,D^2}{4} \times F_s.$$

According to the conditions of the problem $T = ⅜$ inch or .375, $D = 13/16$ inch or .813, $L = 1\frac{1}{2} \times D$ or 1.2195, $F_t = 60,000$ pounds per square inch, $F_s = 42,000$ pounds per square inch for the rivets, and 45,000 pounds per square inch for the plate. The value of F_c may be taken as 90,000 per square inch for both the rivet and plate.

Using the above values, the strength of the joint to resist failure by crushing either the plate or the rivet $= F_c \times T \times D = 90{,}000 \times .375 \times .813 = 27{,}440$. The resistance of the joint to failure by shearing the plate from the center of the rivet to the edge $= 2 \times F_s \times T \times L = 2 \times 45{,}000 \times .375 \times 1.2195 = 41{,}158$.

$$\text{The resistance to shearing the rivet} = \frac{3.1416\,(.813)^2}{4} \times 42{,}000 = .7854 \times (.813)^2 \times 42{,}000 = 21{,}803.$$

A well-designed joint will seldom fail in any of the above ways, although in this particular joint the strength to resist shearing the rivet is the least, and the joint would probably fail in this way.

Q.—What is the real cause of the breakage of stay-bolts in a locomotive boiler? Are the stay-bolts sheared off or does the unequal expansion of the inner and outer sheets bring an excessive tensile stress on the bolt? A SUBSCRIBER.

A.—The stay-bolts in a locomotive boiler are seldom sheared off. The reason for their failure is that the greater expansion of the inner fire-box sheet brings a load upon the stay-bolt, which may be considered to act at right angles to it and to be applied at the fire-box end. The amount of the load depends upon the difference in the displacement of the two sheets, caused by the greater expansion of the inner sheet. The stay-bolt may be considered as the cantilever beam firmly fixed in the outside sheet and loaded at the inner sheet. This force acting at the inner end of the stay-bolt at right angles to its axis causes a tension stress on one side of the bolt and a compression stress on the opposite side. The tensile stress thus produced added to the direct tensile stress on the bolt, due to the steam pressure between the sheets, is plainly in excess of the simple tension stress due to the steam pressure, for which stress the strength of the bolt was figured. It is this excessive stress which causes the breakage of the stay-bolt rather than any shearing action. It will be seen that in the case of a flexible stay-bolt this action is avoided, as the end which is secured to the outside sheet is movable, and therefore the bolt will not be called upon to withstand any greater pressure than that caused by the pressure of the steam upon a certain area of the sheet.

ENGINEERING SPECIALTIES.

"Nyflexmet" Expansion Joints.

Since expansion and linear distortions, due to changes of temperature in a steam or other high-pressure pipe line, always act in the direction of the axis, practically unlimited expansion and perfect freedom of motion could be obtained by breaking the line of pipe at some point, leaving the end free in space. This is what is done in the case of the new "Nyflexmet" compensators, now placed in the American market for the first time by the New York Flexible Metallic Hose & Tubing Company, 173 Lafayette street, New York.

At some suitable place the continuity of the line is broken. Where the pipe is carried on it is no longer in line with or an

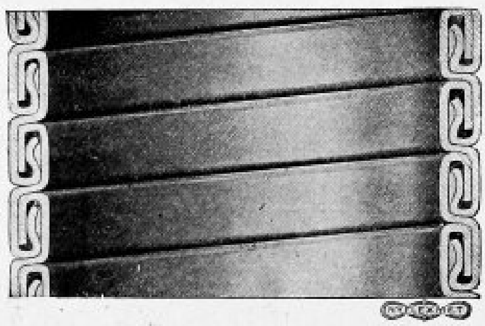


FIG. 1.—SECTION OF HOSE SHOWING FLEXIBLE CONSTRUCTION.

extension of that part on the other side of the break. The two ends are connected by suitable lengths of very strong, yet perfectly flexible metallic hose, forming a pressure-tight union with each pipe, and yet in no way obstructing their movement endwise, because the connector is put in at right angles to the line. In some respects the flexible insert is similar in action to the leather sides of a bellows, offering no obstruction to movement between the top and bottom, yet keeping the whole perfectly tight. The flexible metallic insert piece is made of "Nyflexmet" hose. For these joints it is made of steel or copper ribbons spirally wound, with interlocking edges, as shown in

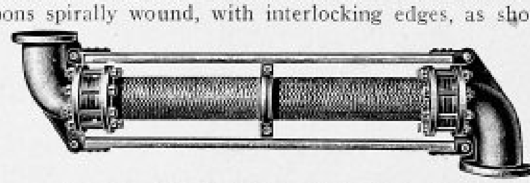


FIG. 2.—ONE FORM OF EXPANSION JOINT.

Fig. 1. Asbestos packing under the edge of the lips ensures tightness, while the great natural strength of the metal wall is very much enhanced by a single or double sheathing of woven, flat-pressed steel wires conformed to the surface by special braiding machinery.

Special cast-flanged connectors form the means of junction between the main pipe line and the "Nyflexmet" movable expansion pieces. They are suitably packed and united by through bolts, which not only set out the packing ring, but also ensure proper hold of the connector casting on the steel-woven sheathing of the hose section, by means of a suitable internal taper in the casting which firmly grips the sheathing.

No thread need be cut in the hose for this screwed connection, as its spiral construction produces naturally a continuous thread, admirably adapted for making secure joints.

From this description it is evident that while an absolutely pressure-tight connection is formed the pipe ends are as free to come and go as if they were wholly disconnected.

The construction of "Nyflexmet" expansion joints is modified in different cases, so as to be especially adapted to the particular run of piping and the local conditions obtaining in each case. Furthermore, this arrangement renders it possible to make any naturally-occurring bends or branches in the line of pipe useful in allowing for expansion and contraction. For instance, two lines of pipe at right angles to each other may be provided with an expansion joint by inserting between them a double V-shaped expansion joint of flexible metallic hose, which avoids the necessity of introducing bends not otherwise requisite, such as spring elbows. For straight lines of piping, U and Z-shaped expansion joints are provided, equipped with

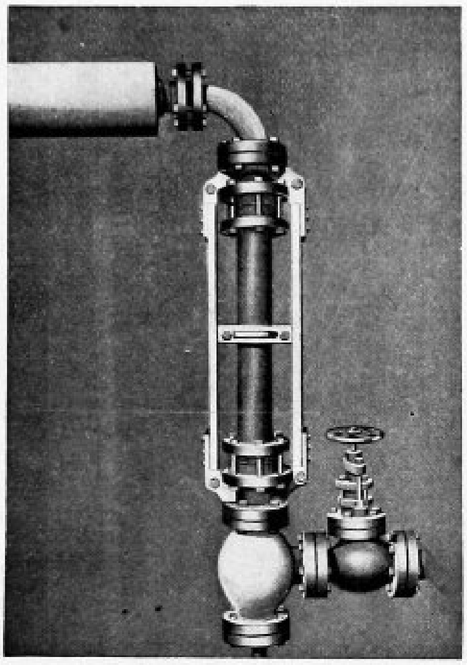


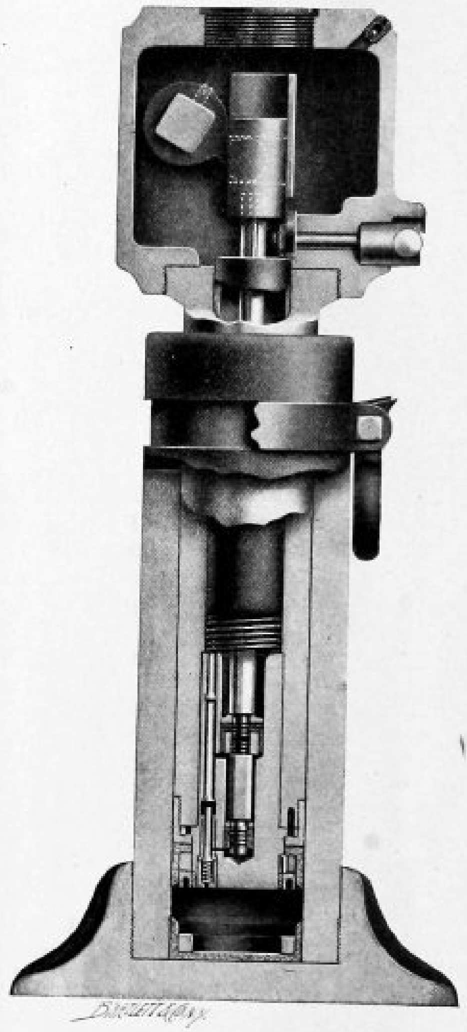
FIG. 3.—I-SHAPED COMPENSATOR IN STEAM SUPPLY PIPE.

one or two flexible hose legs. The latter must be inserted in the middle of the run of piping, in order to obtain full benefit of the compensating capacity of both hose legs. Single I-shaped expansion joints are inserted when the line of piping which is to have its expansion provided for must be connected with a second line running at right angles to it.

These lengths of "Nyflexmet" hose are not inserted in the line of piping without due provision for limiting the distortions and stresses to which they could possibly be exposed. From the cuts it will be seen that rods are disposed at either side, passing through and connecting with a pipe clip, secured to the hose leg at mid-length. The combination forms the so-called "limiting parallelogram," which prevents straining of the hose, by distributing uniformly throughout its length any bending stress to which it may be subjected, causing it to bend in the form of an S. Owing to this provision for limiting distorting stresses, and owing to the great specific strength of "Nyflexmet" hose to resisting pressures amounting to 900 pounds per square inch and more for pipes up to 8 inches internal diameter, this form of expansion joint is said to insure absolute safety up to the extreme limits of pressures occurring in practice.

The Universal Hydraulic Jack.

The universal hydraulic jack, manufactured by Richard Dudgeon, Broome and Columbia streets, New York City, is constructed with two pumps, so that if the load is light or if the ram must be extended some distance before the strain commences, the two pumps can be used together until the strain becomes excessive, when one pump is thrown out by a turn of the handle. Reversing the operation throws both pumps into



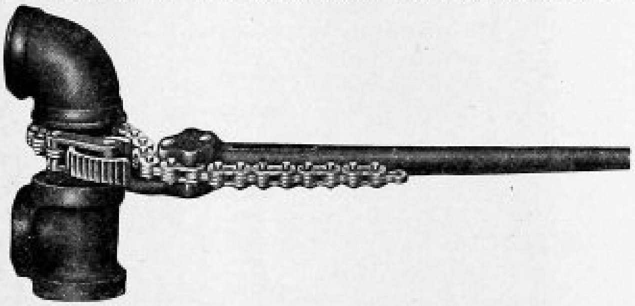
UNIVERSAL HYDRAULIC JACK.

service again. The jack is unique in that the position of the valve handle always shows the position of the valves. The valves are all assembled in one chamber and are reduced to a minimum number. While other two-pump jacks require three pressure valves and two suction valves, the "Universal" jack has but one pressure valve and two suction valves. All three valves are contained in one passage, and any one alone can perform the functions commonly shared by the three.

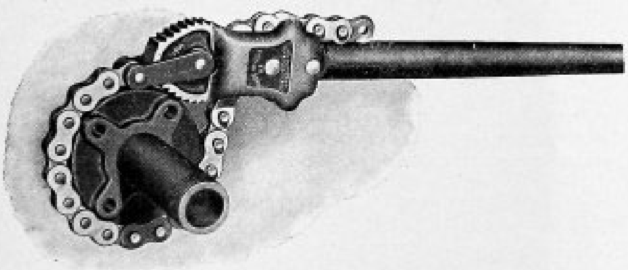
This jack can be operated either vertically or horizontally and with the lever working at any angle. It can be lowered either by the valve handle or the lever, or it can be furnished so as to lower by either method alone. The jack is operated in the usual way with the special valve handle. When both pumps are used the valve handle is turned to the left. When one pump only is required it is turned straight downward. The jack is lowered by turning the valve handle to the right or by using the lever in the ordinary manner. The sectional view of the jack shows the arrangement of the valves and pumps.

"Agrippa" Fittings Wrench.

A drop-forged wrench for use on pipe fittings which gets into the tight, narrow places and bites on irregular surfaces where a broader chain wrench would fail is being placed on the market by J. H. Williams & Company, 150 Hamilton avenue, Brooklyn, N. Y. It is claimed that this wrench greatly re-



AGRIPPA WRENCH APPLIED TO AN ELBOW.

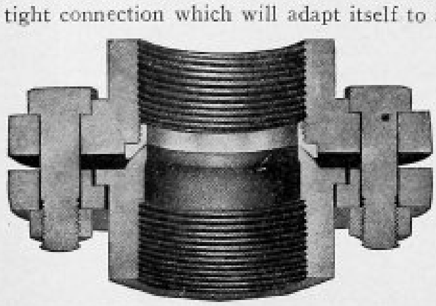


AGRIPPA WRENCH APPLIED TO A PIPE FLANGE.

duces the trouble and annoyance which is always occasioned when handling short nipples and flange connections or jobs with a variety of outlets. The wrench has a narrow, powerful jaw for both pipe and fittings. The "Agrippa" wrench is the outcome of the Vulcan chain pipe wrench, which has stood the test of many years' service.

The "Kewanee" Flange Union.

The fact that serious trouble may be caused by the failure of rubber gaskets in steam pipe joints has caused the Western Tube Company, Kewanee, Ill., to place upon the market a flange union in which no gasket is needed. From the sectional view of this union it will be seen that there is a brass to iron joint which has a ball-bearing surface. It is claimed that this insures a tight connection which will adapt itself to any slight

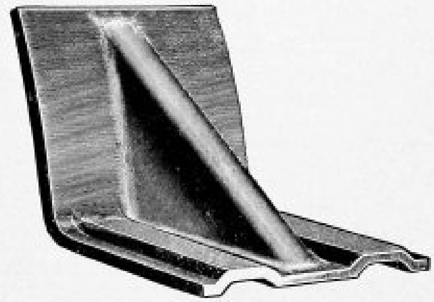


SECTION OF KEWANEE FLANGE UNION.

change in the alignment of the pipe caused by sagging, straining, expansion, etc. The entire joint with the exception of the seat is made of malleable iron so that the flange may be screwed up tightly without danger of cracking. One of the malleable flanges is movable; therefore, both ends may be screwed up tightly on the pipe after which the ring or flange can be slipped on and the bolts inserted. With this arrangement the difficulty of "matching" the holes for the bolts is avoided, since the ring is free to move and can be adjusted to receive the bolts in whatever position they come.

Best's Patent Steel Boiler Lug.

A very practical boiler lug is placed on the market by Joseph T. Ryerson & Son, of Chicago, which is known as Best's patent pressed steel boiler lug. The lug is pressed from flanged steel plate. Its sides are sheared and it is finished while hot, all in one heat. The bases of all lugs 54 inches and larger are sheared to an exact length. The lug is so designed that it does not interfere with triple and quadruple riveted joints, which are ordinarily used on boilers. It has a wide

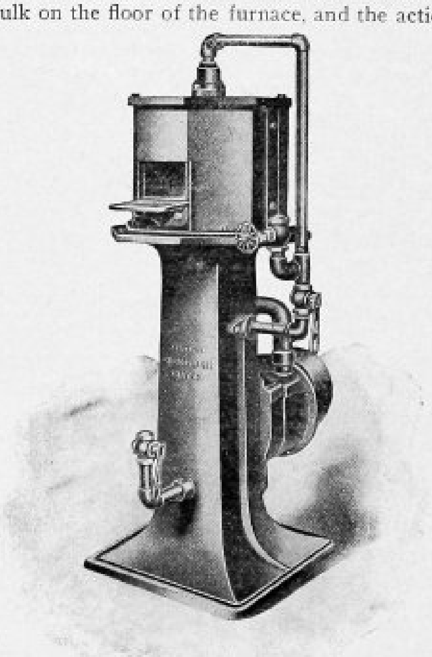


STEEL BOILER LUG.

bearing on the shell and there are grooves in the bottom of the bracket for the purpose of receiving the rollers. These grooves prevent the rollers from getting out of position, an occurrence which frequently happens when the brick work gets loose, if the bottom of the bracket is smooth. These brackets are manufactured for all sizes of boilers from 30 to 84 inches in diameter.

A Gas-Fired Rivet Heating Furnace.

A convenient form of gas-fired rivet heating furnace is shown below, in which the flame is projected downward from a single burner, placed on the top of the forge. The rivets are placed in bulk on the floor of the furnace, and the action of the



NO. 2 RIVET HEATING FURNACE.

flame is such that the heating is rapid and uniform. The burner can be easily controlled, and, therefore, overheating can be avoided. Almost any kind of gas fuel may be used with this furnace, illuminating gas, natural gas or gasoline gas, and burners can be provided for crude oil or kerosene. It is claimed that the burners produce a uniform mixture, making no noise, soot or odor. All standard furnaces are arranged with an air reservoir in the base with a pressure blower direct connected. The linings are extra heavy, reducing radiation to the minimum, and the very best workmanship and materials are used throughout the construction. The Chicago Flexible Shaft Company, La Salle avenue and Ontario street, Chicago, Ill., are the manufacturers.

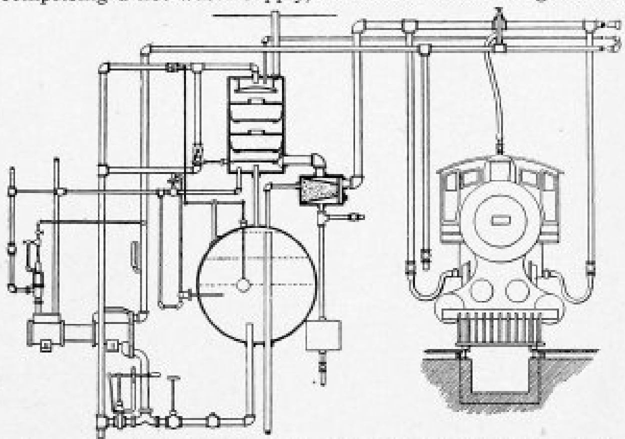
SELECTED BOILER PATENTS.

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.

847,388. SYSTEM OF WASHING AND FILLING LOCOMOTIVE BOILERS. William White, of Chicago, Ill.

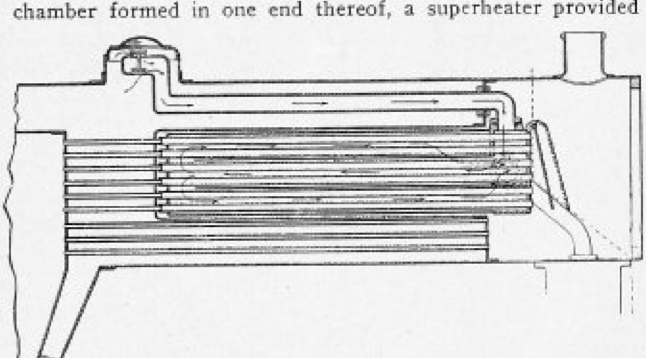
Claim. A locomotive boiler washing and filling system, comprising a hot-water supply, means for maintaining the hot



water at constant temperature and a cold-water supply, a distributing-pipe, and means for admitting to the distributing-pipe hot and cold water in fixed predetermined proportions. Six claims.

847,407. STEAM GENERATOR AND SUPERHEATER. Frank A. Haughton, of Schenectady, New York.

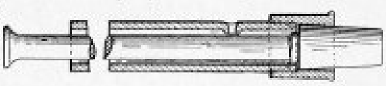
Claim. The combination with a tubular boiler having a chamber formed in one end thereof, a superheater provided



with fire-tubes located in the chamber, the tubes of the superheater registering with corresponding tubes of the boiler. Twenty-one claims.

855,735. FLUE-PLUGGING DEVICE. William H. Tracy, Folkstown, Ga.

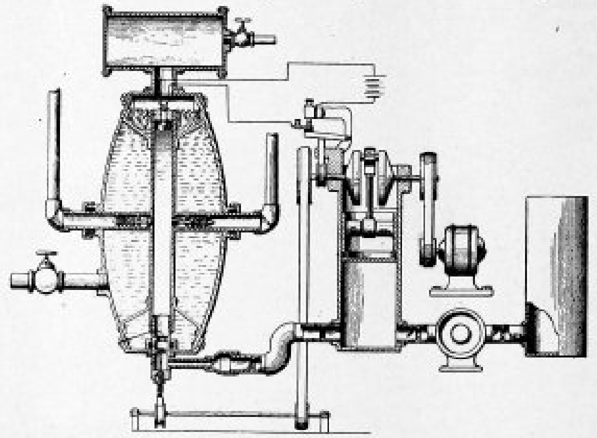
Claim.—A device for plugging boiler-flues, consisting of a tube having a forwardly-open enlargement at its forward end



for the reception of the butt-end portion of a plug, a plugging rod endwise movable in said tube and having an enlarged forward end, and a stop projecting inward from the wall of the tube in rear of said enlarged forward end and adapted to cooperate therewith to prevent the rod sliding rearward out of the tube. One claim.

850,191. STEAM GENERATOR. Joseph M. Story, of Owosso, Mich.

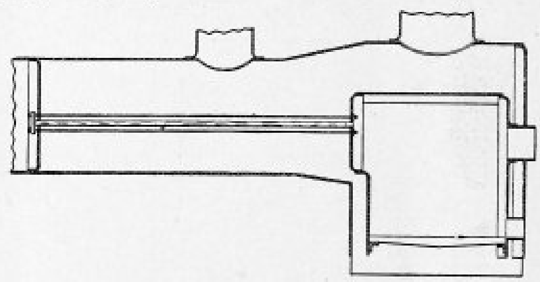
Claim.—In a steam generator of the class described a boiler, an explosion chamber supported within the boiler, means for intermittently admitting explosive gases into the explosion



chamber, intermittently operating means for igniting said gases, escape pipes connected with the explosion chamber and extending through packing glands in the walls of the boiler and spring actuated escape valves within said pipes normally engaging escape ports in the side walls of the combustion chamber. One claim.

850,299.—ART OF SETTING BOILER TUBES. William M. Dickerson, of Indianapolis, Ind.

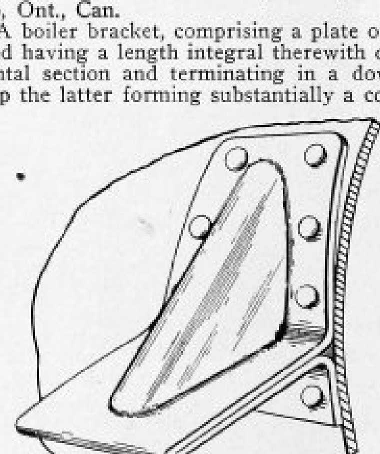
Claim.—That improvement in the art of setting boiler flues



or tubes which consists in forcing them into a tapered opening and expanding their outer ends while under the forcing pressure. Five claims.

848,890. BOILER BRACKET. James Jenkins Fletcher, of Toronto, Ont., Can.

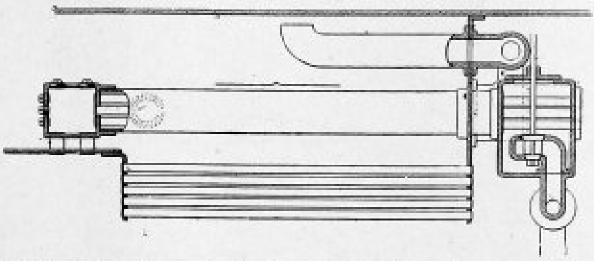
Claim.—A boiler bracket, comprising a plate of metal angularly formed having a length integral therewith doubled under the horizontal section and terminating in a downwardly depending flap the latter forming substantially a continuation of



the upper vertical section, and the said flap and the said vertical section having suitable rivet holes there-through, and the said horizontal and upper vertical sections having a hollow strut formation integral therewith and extending centrally in a direct line to a point intermediate of the length of said vertical section to a point intermediate of the length of said horizontal section and merging into the flat surface of said plate and into the angle at each side intermediate of the width of said sections, substantially as described. One claim.

849,875. SUPERHEATER FOR LOCOMOTIVES. Henry V. Wille, of Philadelphia, Pa., assignor to Burnham, Williams & Co., of Philadelphia.

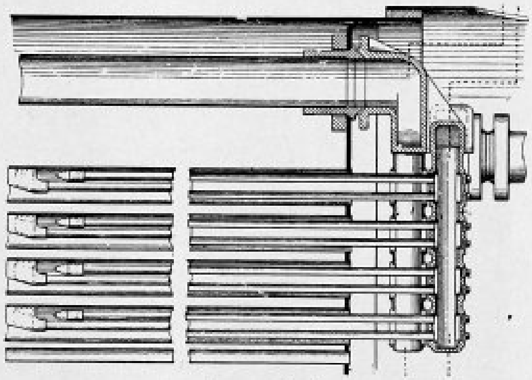
Claim.—The combination of a boiler having a front tube sheet, a fire-box, a rear tube sheet separating the fire-box from the body of the boiler, a crown for the fire-box, tubes extending from the rear tube sheet to the front tube sheet, a superheater mounted within the upper portion of the boiler



and extending through the front tube sheet, the rear end of the superheater resting upon and supported solely by the crown of the fire-box and connected to the fire-box, a steam supply pipe extending from the upper portion of the boiler and communicating with the superheater, and pipes in the smoke-box leading to the cylinders and also communicating with the superheater. Eight claims.

850,565. SUPERHEATER. Francis J. Cole, of New York, N. Y., assignor to American Locomotive Company, of New York.

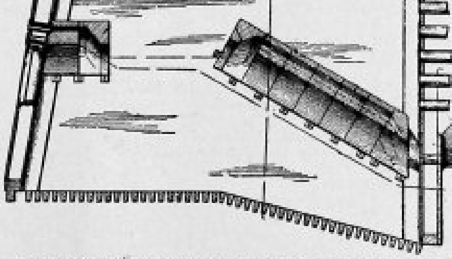
Claim.—The combination, with a tubular steam boiler, of a superheating tube, a pair of superheater pipes extending longitudinally therein and connected at their rear ends, a vertical



saturated steam header located in front of the superheating tube and connected to the forward end of one of the pair of superheater pipes, a similarly located vertical superheated steam header having its walls entirely separated from those of the saturated steam header and connected to the forward end of the other superheater pipe, and a T-head comprising a supply compartment communicating with the saturated steam header and a delivery compartment communicating with the superheated steam header. Five claims.

851,329. LOCOMOTIVE BOILER FURNACE. Evan H. Wade and John L. Nicholson, of Chicago, Ill., assignors to American Locomotive Equipment Company.

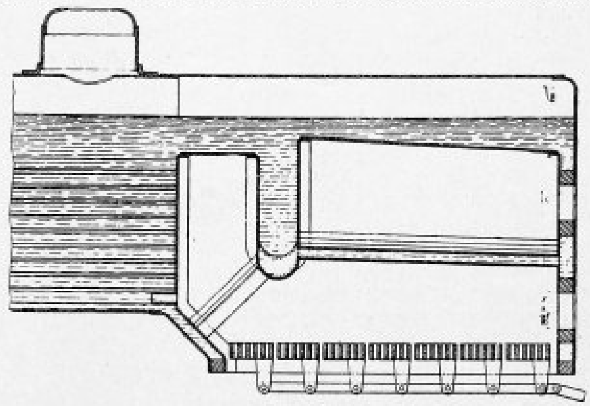
Claim.—A locomotive boiler furnace, in combination with a front arch occupying an inclined position in the furnace and



having its lower end abutting the flue sheet of said furnace and the upper part of said arch comprising longitudinally channeled refractory bricks, and the upper and lower bricks of said arch containing transverse channels, the latter communicating with the outer air. Seven claims.

851,088. BOILER FURNACE. Alonzo L. Hastings, of Allegheny, Pa.

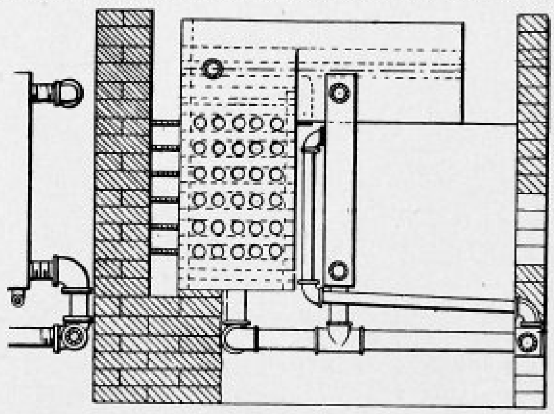
Claim.—A boiler furnace having its flue chamber partially separated from the furnace by a water space, a series of water



tubes communicating with said space at one end and with a rear water leg at the opposite end and forming a grate, and a second series of tubes communicating with such space and into the front water leg and extending across the path of the gases where they enter the flue chamber. Five claims.

852,481. STEAM BOILER. David Wigert, of Greenbush, Ill.

Claim.—The combination with a boiler having an auxiliary water heater spaced therefrom and in front of the main body of the boiler, of a water box arranged at the front of the fire box, a grate formed of independent tubes, each tube having a



short vertical section connected to the water box, an approximately horizontal section extending rearwardly from the vertical section and forming a fuel supporting surface, and an upwardly extending section arranged between the boiler and the auxiliary heater and connected to the upper portion of the latter, and circulating pipes connecting the water box to the lower end of the boiler proper and to the lower end of the auxiliary heater. Two claims.

853,182. STEAM GENERATOR. Thomas Lowther, of Ekaterinoslaf, Russia.

Claim.—In a steam generator, a plurality of horizontal and transversely arranged drums located in sets one above the other, said sets of drums being in communication with each other at their ends and the transverse drums thereof arranged to form an undulating path between the sets. Sixteen claims.

847,386. SYSTEM OF WASHING AND FILLING LOCOMOTIVE BOILERS. William White and Spencer Otis, of Chicago, Ill.

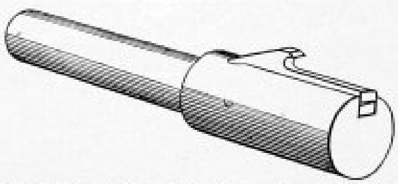
Claim.—A locomotive boiler washing and filling system, comprising washout and filling water supply means, and means for separating the entire fluid contents of a locomotive boiler and for mingling the separated contents with the washout and filling water respectively. Eight claims.

854, 061. HAND-HOLE PLATE FOR BOILERS. Robert Clark Stevens, Indianapolis, Ind.

Claim.—The combination with a header or other sheet provided with a truly circular untapered unflanged opening therein, of a round closure therefor, of larger diameter than the opening, said closure being flatter on two opposite sides to permit its passage through the opening, the distance between the flatter portions being approximately equal to the diameter of the opening. Ten claims.

855,363. FLUE-BEADER TOOL. Lewie A. Tinnes, Bird Island, Minn.

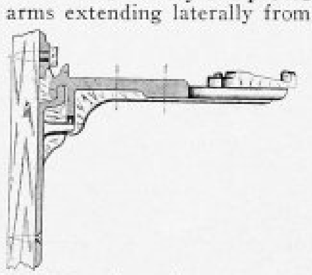
Claim.—A flue working device comprising a shank having a head provided with a longitudinal laterally opening slot, a



tool movably arranged in said slot and provided with a projecting portion having an undercut forming surface, and a spring arranged beneath the tool for pressing the same yieldably to active position. Two claims.

855,453. BOILER-SUPPORT. Charles H. Foster, St. Louis, Mo.

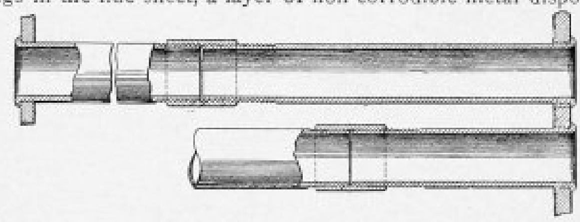
Claim.—In a boiler support, the combination with a wall bracket, of an arm carried thereby and provided with a bearing for the boiler, arms extending laterally from said first named



arm, and removable bearing pieces for the boiler carried by said second named arms, the spaces between said arms and bearing pieces forming recesses constituting receptacles for the fastening means for the bracket. Three claims.

856,516. BOILER-FLUE. John H. Davenport, Grand Island, Neb.

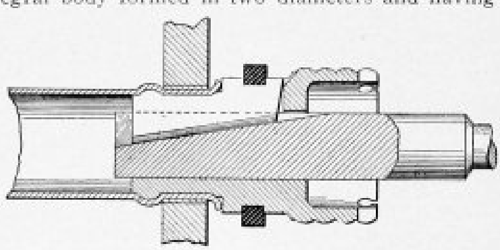
Claim.—A boiler comprising front and rear flue sheets, stubs extending through the rear flue sheet, the outer ends of said stubs having beads thereon overlapping the walls of the openings in the flue sheet, a layer of non-corrodible metal disposed



upon and covering the inner face of the rear flue sheet and surrounding the stubs and constituting a solder, main flue sections within the front flue sheet, and means between and spaced from the flue sheets for coupling together the inner face of the main flue sections and the stubs. One claim.

856,896. TUBE EXPANDING AND BEADING TOOL. Washington McCormick, Hillyard, Wash.

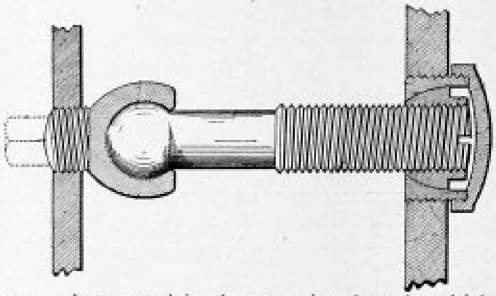
Claim.—A tube-expanding and beading device, comprising an integral body formed in two diameters and having a cen-



tral bore and a plurality of slots extending lengthwise and leading to said bore, a mandrel fitting said bore and formed with a plurality of longitudinal recesses having inclined bottom portions curved in cross section and registering with the slots of the body, and a plurality of expanding and beading tools fitted the said slots and said recesses, and having curved inner edges. Three claims.

856,977. FLEXIBLE STAY-BOLT. Thomas H. Mooney, Houston, Tex.

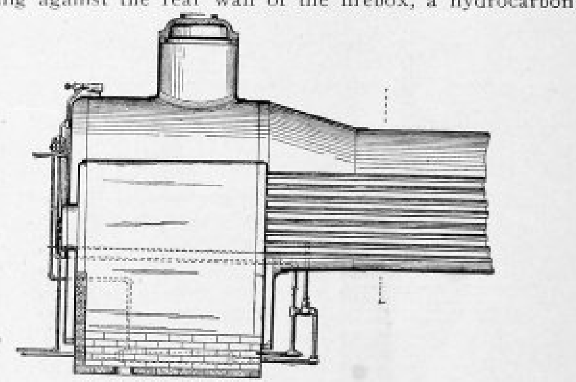
Claim.—The combination with a pair of boiler sheets, of a cup fixed to one of the sheets, a stay bolt, a spherical head integral with one end of the stay bolt which head is seated in



the cup, a socket seated in the opposite sheet in which socket is formed a semicircular seat, a nut adjustably seated on the end of the stay bolt opposite the end provided with a head and which nut has a curved surface adapted to fit the semicircular seat in the socket, and a cap detachably secured to the socket and which encloses the nut and end of the stay bolt. One claim.

857,170. OIL-BURNING STEAM-BOILER. Taylor W. Heintzelman and James G. Camp, Sacramento, Cal.

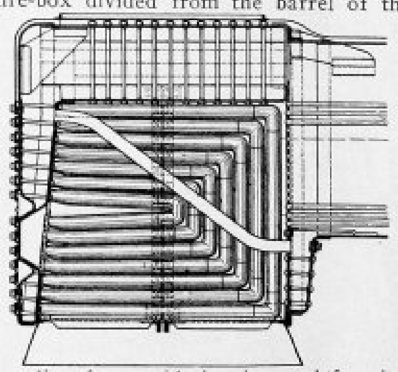
Claim.—The combination, with a firebox of a locomotive boiler, of a fire brick lined ash pan extending continuously from the front to the rear of the firebox, a fire brick lining abutting against the rear wall of the firebox, a hydrocarbon



burner extending into the firebox at or near the front end thereof and having an uninterrupted discharge therefrom to said rear lining, and a direct draft opening formed in the bottom of the ash pan adjacent to the rear end thereof, whereby the passage of heat from the burner is permitted throughout the length of the firebox and a flame is turned back toward the tube sheet to effect complete combustion. Three claims.

859,155. STEAM BOILER. Henrik Christian Vogt, of Copenhagen, Denmark.

Claim.—In a steam boiler of the locomotive type, a chamber above the fire-box divided from the barrel of the boiler, a



chamber depending from said chamber and forming the front of the fire-box, tubes forming the sides of the fire-box and each connected to said depending chamber at different levels, and water tubes connecting the water space of the chamber above the fire-box with the lower part of the water space of the boiler barrel. Seven claims.

THE BOILER MAKER

VOL. VII | OCTOBER, 1907 | No. 10

CYLINDRICAL BOILER FURNACES.

Development of Modern Suspension Furnace, and Methods of Manufacture.

The various types of cylindrical boiler furnaces may be divided into the following classes: First, plain cylindrical tubes with a straight longitudinal section throughout the entire length. Second, plain cylindrical tubes strengthened by means of flanges, hoops, corrugations or ribs at intervals throughout their length. Third, furnaces whose entire longitudinal section is wholly curvilinear.

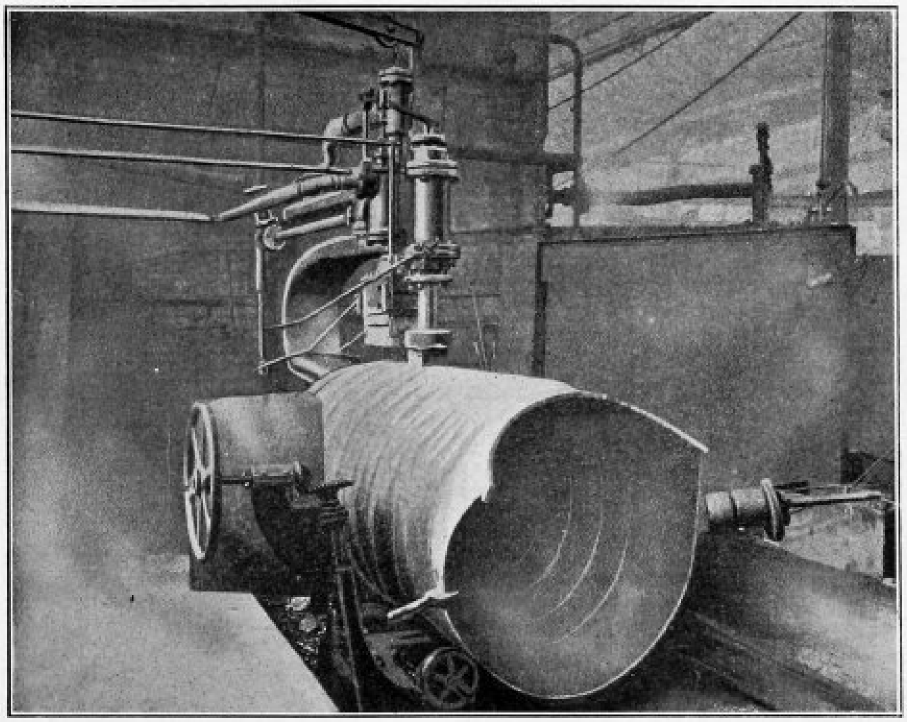


FIG. I.—WELDING MACHINE FOR CORRUGATED FURNACES.

The strength of a plain cylindrical tube has been found to vary directly as its thickness and inversely as its diameter. Furnaces with large diameters in proportion to their length are, however, weaker than this proportion. This is the case when the ratio of diameter to length is greater than .166. No doubt this is due to the difference between the conditions of the material under stress in a perfect cylinder and in the imperfect cylinder, which must always be dealt with in practice.

Since boiler furnaces are subjected to a uniformly distributed external pressure, formulas for the collapsing pressure, or collapsing coefficient, have been deduced by testing the various types of furnaces under cold water pressure when inclosed in a strong steel cylinder. The form of apparatus used for such a test is shown in Fig. 3. The ends of the furnace are riveted to the flanges of the test tube and then the cylinder is filled with cold water, the pressure of which is raised until the furnace collapses. A coefficient of resistance to collapse has been obtained from such tests by the following formula:

$\frac{P \times D}{T}$ = collapsing coefficient, where P = collapsing pressure in pounds per square inch; D = outside diameter of furnace in inches, and T = thickness in inches.

Although collapsing coefficients figured by the above formula are accepted by boiler manufacturers as indicating the comparative strength of different types of furnaces, it will be seen that there is an opportunity for confusion in applying the formula. For instance, the diameter D is sometimes taken as the least external diameter and sometimes as the greatest external diameter, depending on whether the furnace is ribbed or corrugated. As the least *inside* diameter is more nearly the true measure of the grate surface, it would seem that the least external diameter would be better suited for the purpose of calculation for all types of furnaces.

Another feature which is not taken into consideration in this formula is the strength of the material. It is evident that of two furnaces of exactly the same dimensions, the one which is built of steel which has a tensile strength of 68,000 pounds per square inch, is capable of resisting a greater pressure than the one which is constructed of steel of 60,000 pounds tensile strength.

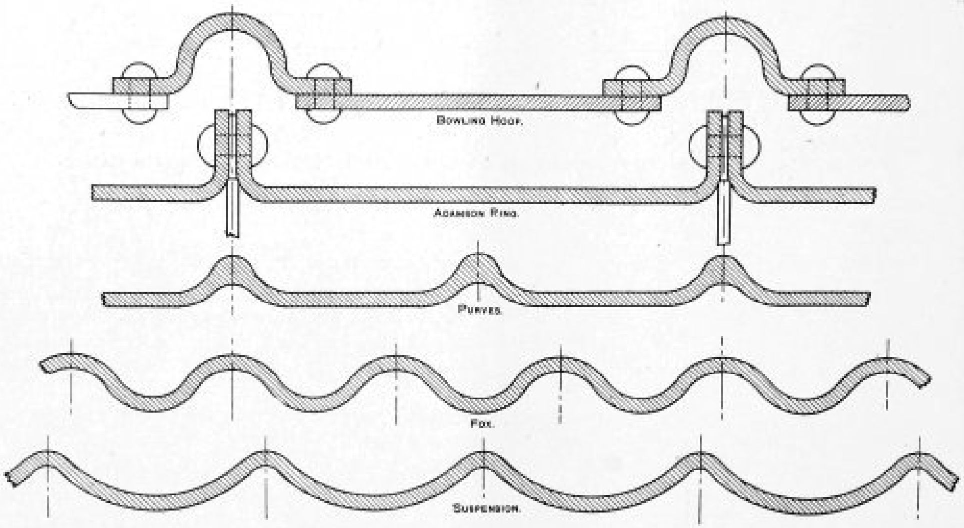


FIG. 2.—SUCCESSIVE STAGES IN THE DEVELOPMENT OF THE SUSPENSION FURNACE.

The conditions under which the cold water test is made for determining the strength of the furnaces are so different from actual conditions when the furnace is installed in the boiler that here again lies a chance of over-estimating the strength of the furnace. When installed in a boiler the furnace is subjected to varying degrees of heat at different places, and is further strained by the movement of the parts of the boiler to which it is connected, due to their expansion and contraction. Furthermore, there is always considerable sediment, dirt, grease and oil contained in boiler-feed water, and this is very quickly deposited over the surface of the furnace, quickly reducing its conductive properties in the places which are so covered. This leads to overheating and sometimes burning of the steel. All these things affect the strength of the furnace, so that it really is unable to withstand the pressure indicated by a cold water collapsing test, and a reasonable allowance should be made for these conditions of service when calculating the strength of the plates.

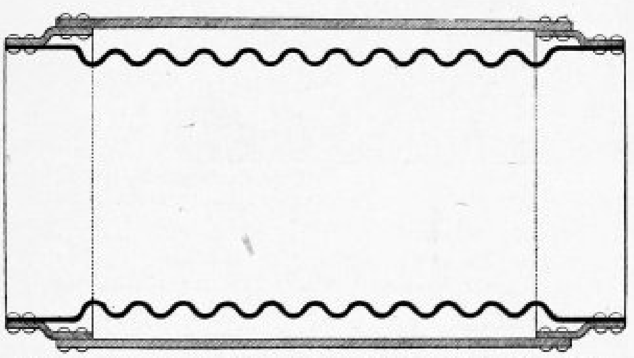


FIG. 3.—SECTION OF FOX FURNACE IN TESTING APPARATUS.

With a given weight of material, the maximum resistance to collapse under uniformly distributed external pressure is offered by a mathematically true cylinder, for the reason that the stress throughout the material in this case is of the same character, namely, compressive. In actual practice, however, it is impossible to construct a boiler furnace which will be a mathematically true cylinder, and even if it were possible to do this such a form could not be maintained in service. Any change in shape from the true cylindrical form tends to change the nature of the stresses at different points, so that they will be unequally distributed throughout the structure. The general effect of initial deformation is to produce circumferential bending stresses instead of the uniform compressive stress to which a mathematically true cylinder is subjected when under external pressure.

In view of the above consideration it is evident that a cylindrical furnace must be strengthened to resist the bending stresses caused by its imperfections in shape. If it were possible to thicken the metal of which the furnace is made this problem would present no difficulty. Since, however, the exchange of heat from the furnace gases to the water in the boiler is greatly affected by the thickness of the furnace shell, it is necessary to keep this as small as possible. Furnaces are never made of plate heavier than ¾ inch in thickness, and are usually much lighter.

About the earliest device which was used to strengthen a cylindrical furnace was the fitting at equal intervals throughout the length of the furnace of annular rings, such as

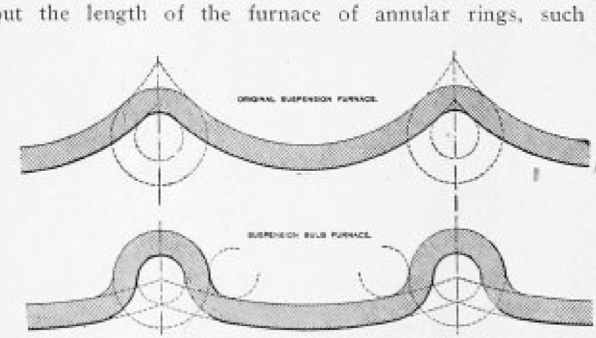


FIG. 4.—THE POINT OF SUSPENSION WAS LOWERED BY MEANS OF A BULB CORRUGATION.

Bowling hoops (Fig. 2), which possess a much greater resistance to collapse than the plain portions of the cylinder between the rings. If the cylinder is thus provided with stiffening rings it is evident that these rings will not be deformed under a stress which is quite sufficient to collapse the intervening metal. Thus they form fixed points of support between which the thin metal of the furnace can only deform by a linear expansion. No such deformation can take place between the rings which does not impose a bending stress upon some portion of the furnace. Obviously the shorter the distance between these rings or points of support the stronger will be the longitudinal section considered as a beam.

As an illustration of how such a deformation as has been mentioned above can take place, consider the case of a plain furnace which, subject to the conditions of local practice, is not a perfect cylinder, but which has been reinforced with outside rings at intervals throughout its length. If a coating of scale accumulates at some place on the outside of the furnace between the rings, the metal immediately below the deposit in the course of time becomes so overheated and weakened that it cannot resist the ordinary steam pressure. Taking this affected area of the plate it may be considered as a flat strip supported at the ends by strong girder rings and partially supported at the sides by the adjacent portions of the furnace shell, which have not been heated to such an extent. This forms, then, a beam flat in longitudinal section, slightly curved in cross-section, supported mainly at the ends and partially supported at the sides. The central portion of this beam, becoming overheated and plastic, deforms inwardly by bending, and it is this weakness of form which determines the ultimate strength of all cylindrical furnaces which are plain or straight for any portion of their length.

There are only two means of strengthening such a furnace: first, by increasing its thickness, to which we have seen there are very decided limits; and, second, by shortening the distance between the strengthening rings. Fig. 2 shows the development from the earlier methods of strengthening cylindrical furnaces to the modern form of suspension furnace. The earlier forms, such as the Bowling hoop and Adamson ring, involve the use of numerous riveted joints, which were a weak factor in these furnaces. Mr. Purves was the first to develop the idea of combining the strengthening ring in the metal of the furnace itself, so that the distance between rings could be greatly reduced. To increase the strength of the furnace the metal in the ridges was made thicker than that in the wall, and as this thicker metal was somewhat protected from the flames it did not, as might be expected, have any tendency to burn. The unequal distribution of metal did, however, cause an unequal distribution of stresses, which caused many circumferential cracks; thus this design was subjected to many modifications.

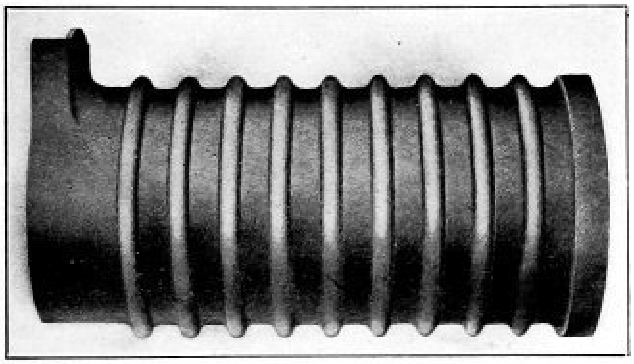


FIG. 5.—A SUSPENSION BULB FURNACE.

One furnace which might be termed a modification of the Purves is the Fox, in which the entire longitudinal section is curvilinear, the ridges and valleys being equal and the curve regular. This furnace was a marked advance in design, as it did away entirely with flat or plain surfaces, which were the main source of weakness in a cylindrical furnace. While this furnace showed great strength when tested with cold water in the laboratory, yet it was found in actual practice that the valleys became filled with a deposit, and this caused overheating of the plates. Other difficulties were also encountered with this furnace, due to the partial stagnation of gas in the corrugations, so that the full benefit of the heating surface could not be realized.

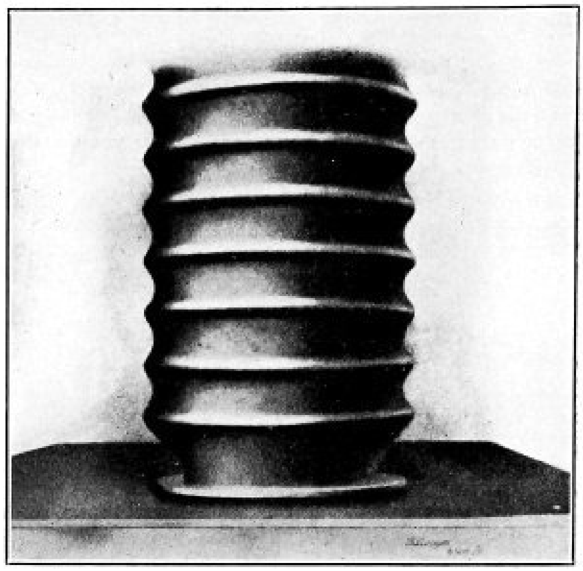


FIG. 6.—FURNACE PLATE WITH THICKENED END.

The next advance in design was from the Fox to the suspension type. Like the Fox, this was entirely curvilinear and of uniform thickness throughout its length. The ridges, however, were made narrower and the valleys wider. The term "suspension" was applied to this type of furnace because the metal which is in the valleys becomes hotter than the metal in the ridges, which are partially protected from the heat, and this hot metal becoming to a certain degree plastic, may be considered to be directly suspended at each end from the cooler and stronger ridges. The metal between the ridges may thus be considered to take the form of a true catenary and to be subject to a simple tensile stress. The metal is, therefore, in a uniform state of tension between the ridges or points of support or in a condition which may very properly be called "suspension." The strength of this structure depends on the ridges, and until they yield the furnace cannot collapse. If local overheating occurs at any one point, pockets,

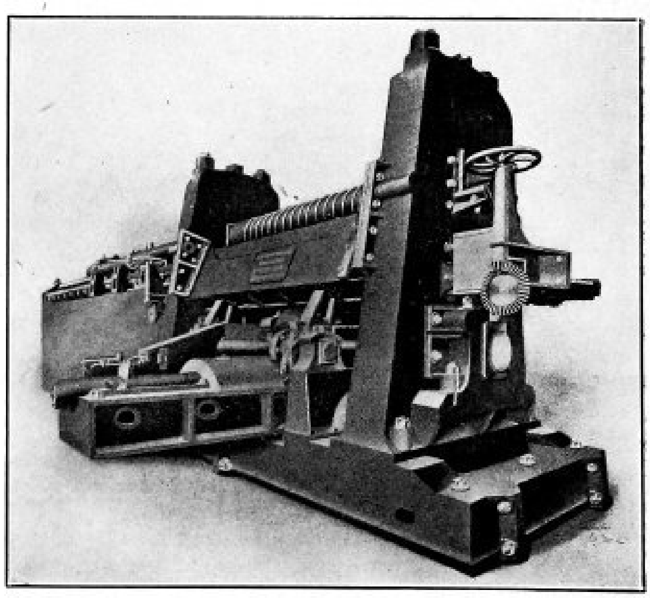


FIG. 7.—MULTIPLE-STAGE CORRUGATING MILL.

or bulges, may be formed, but by making the furnace entirely curvilinear in its longitudinal section and accurately proportioning the curvature of the ridges and valleys, the ridges can be depended upon to so increase the strength of the valleys that the strength of the furnace is considerably greater than the strength of a plain cylindrical furnace reinforced with stiffening rings.

From the above considerations it is evident that the design for a successful furnace depends largely on the correct proportions of the curves. In the original suspension design, shown in Fig. 4, the circular arcs forming the valleys are tangential to the arcs forming the ridges, which are in fact merely the intersections of the extended valleys rounded off.

Since a long suspended valley has been proved in practice to be exceptionally strong in combination with a narrow ridge, several forms of furnaces have been developed in which the valleys are of such radius that the ultimate intersection of their

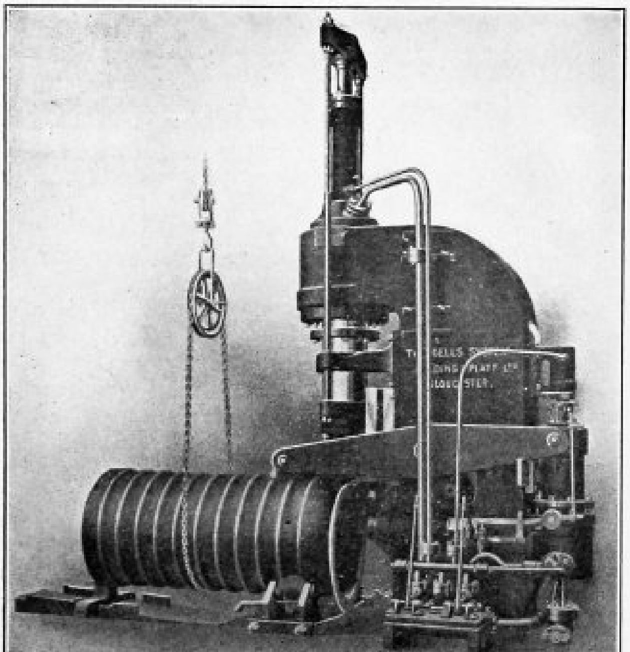


FIG. 8.—DIE PRESS FOR FLANGING FURNACE ENDS.

arcs is below the apex of the ridge (see Figs. 4 and 5). Thus the ridge is practically an independent element or girder from which the valleys are suspended. The metal forming the sides of the ridges is practically normal to the axis of the furnace except that it is rounded off so as to impose as little resistance as possible where the metal undergoes a change of direction. This modification, which is apparently simple, was brought out only as the result of extensive tests, and has proved so effective that when tested by hydraulic pressure the point of collapse in the furnace is found to be within 10 percent of the elastic limit of the material of which it is made.

It is of the utmost importance that only a high grade steel of medium tensile strength and a fair amount of ductility should be used for a boiler furnace; also the process of manufacture should be such that these properties of the steel are in nowise impaired. The metal must also be maintained at a uniform thickness throughout the corrugated section. This feature has been hard to maintain, as when the furnaces are made from a plate of uniform thickness there is a stretching and consequent thinning of the metal at the crowns and on the sides of the ridges. A machine, shown in Fig. 7, has been designed by Mr. Ernest Gearing, of Leeds, England, with which it is possible to roll furnaces without stretching or thinning the metal in the ridges. The furnace plates should always be thickened at one end to allow for thinning during flanging (see Fig. 6), and the flanging should be done by hydraulic pressure in dies, as shown in Fig. 8, otherwise the material is liable to crack.

In the manufacture of corrugated furnaces the ingots are usually cast in sizes to enable two flues to be rolled from each. They are slabbed down in a roughing mill and the finishing rolls form the ribs or corrugations. After the plates have been rolled and cut to approximate dimensions, they are placed in a slotting machine and shaped at the ends for flanging. This work is done in pairs, two flue plates being placed back to back, so that the plates will form right and left-hand furnaces, respectively. The pieces cut off from the plates in this operation may be conveniently used for test purposes.

The plates are usually bent in a hydraulic press, one form of this machine, consisting of a table carrying adjustable ribs on which the part of the plate to be bent rests, while under it are three cylinders used in the bending operation. A fuller or heavy bar is fixed rigidly to the frame work used, but may be removed for the withdrawal of the flue after it is curved. The flat flue plate is placed between the fuller above and the supporting ribs below, and the latter rising by the operation of the hydraulic power bend the plate in successive widths to a curve, the radius of which is regulated by the distance apart of the supporting ribs and the duration of the pressing action. As soon as the curvature conforms to the template prepared, the pressure is removed, the plate advanced to bring a new portion in the fuller and the bending operation repeated.

After being thus formed to a circular shape the flue is taken to the welding machine (Fig. 1). The edges to be welded together are cut on a bevel except at the ends of the flue, where flanges must be formed for connection with the front of the boiler and with the combustion chamber. Square edges are left at these two places, and the thickness is left slightly greater than in the ribbed portion. The weld is made with a glut in the case of the ribbed flue and cambered. In the welding machine shown in the illustration the anvil is carried on one large bracket with a steam hammer over it on another. Arrangements are provided to enable any length or diameter of flue to be supported immediately on the anvil, the position of which is fixed. Both of the arms carry gas furnaces and blowers, coal gas being preferred, because it is considered easier on the metal. The hammer is operated by steam and the work is very quickly and effectually carried out, the flue with its carriage being traversed along immediately under the gas fires and hammer.

After being welded the flue is taken to a hydraulic rounding machine, where any irregularities due to welding are taken out. This tool has a central column against which the flue is pressed by suitable shaping blocks conforming to the various flue sections. The outside block is given a reciprocating motion by hydraulic cylinders, thus pressing the flue against the inner column. The heat at which this shaping operation takes place is between 1,100 and 1,200 degrees F.

The flanges for securing the flue to the shell plate and combustion chamber are next formed in hydraulic presses, and then the flue is trimmed to its exact dimensions by cold band-saws or slotting machines. Finally, the flue is annealed in an upright furnace and air-cooled, so that there is no chance for an alteration in shape. Thus completed the flue is passed on to the boiler maker.

It is announced that a Scotch company is about to manufacture, by a new process known as the Inshaw, seamless iron and steel tubes for boilers. These tubes, it is claimed, will not corrode. It is said that they will be placed on the market at under £7 ($34.07) per ton, or less than the price of iron strips at present used.

New York Laws for Locomotive Boiler Inspection.

The railroad laws of the State of New York, as amended for the year 1907, provide that it shall be the duty of every railroad corporation operated by steam power within the State and of the directors, managers or superintendents of such railroads, to cause thorough inspection to be made of the boilers and fittings of all steam locomotives which are used on their railroads. Such inspections are to be made at least every three months, under the direction of the railroad corporations, by boiler inspectors, who are suitably qualified to judge from the construction and usage of boilers whether they are of sufficient strength, workmanship and general fitness to be used without hazard to life.

All boilers of steam locomotives used in this State must conform to the following requirements: The boiler must be of good and suitable materials; the openings for the passage of water and steam, respectively, and of pipes and tubes exposed to heat shall be of proper dimensions; the safety valves, fusible plugs, low-water glass indicator, gage cocks and steam gages shall be of such construction and arrangement that they may be safely employed in active service without peril to life.

Formerly the Railroad Commissioners were given the power to formulate rules and regulations for the inspection and testing of boilers. An amendment to the public service law, which went into effect July 1, 1907, provides that the Board of Railroad Commissioners shall be abolished, and that all the power and duties of this board shall be exercised and performed by the public service commissions. In accordance with this act, the public service commission of the Second District has prescribed the following regulations for inspecting, testing and washing locomotive boilers:

GENERAL CONSTRUCTION AND SAFE WORKING PRESSURE.

The chief mechanical officer of each railroad company will be held responsible for the general design, construction and inspection of the locomotive boilers under his control. The safe working pressure for each locomotive boiler shall be fixed by the chief mechanical officer of the company or by a competent mechanical engineer under his supervision. The safe working pressure must be determined in accordance with calculations of the various parts after full consideration has been given to the general design, workmanship and condition of the boiler.

INSPECTION OF INTERIOR OF BOILER.

Time of Inspection.—The interior of every boiler shall be thoroughly inspected before the boiler is put into service, and also whenever a sufficient number of flues are removed to allow examination.

Flues to be Removed.—All flues shall be removed at least once every three years and a thorough examination made of the entire interior of the boiler. After the flues are taken out, the inside of the boiler must have the scale removed and be thoroughly cleaned.

Method of Inspection.—The entire interior of the boiler must then be examined for cracks, pitting and grooving. The edges of plates, all laps, seams and points where cracks and defects are likely to develop, or which an exterior examination may have indicated, must be given an especially minute examination. It must be seen that braces and stays are taut, that pins are properly secured in place, and that each is in condition to support its proportion of the stress.

Repairs.—Any boiler developing cracks in the shell shall be taken out of service at once and thoroughly repaired before it is reported to be in satisfactory condition.

Lap-Joint Seams.—Every boiler having lap-joint longitudinal seams without reinforcing plates shall be examined with special care to detect grooving or cracks at the edges of the seams.

INSPECTION OF EXTERIOR OF BOILER.

The jacket and lagging shall be removed at least once every three years, and also whenever the inspector considers it desirable or necessary in order to thoroughly inspect the boiler.

TESTING BOILERS.

Time of Testing.—Every boiler before being put into service, and at least once every twelve months thereafter, shall be subjected to hydrostatic pressure 25 percent above the working steam pressure.

Removal of Dome Cap.—Preceding the hydrostatic test the dome cap and throttle pipe must be removed and the interior surface and connections of the boiler examined as thoroughly as the conditions permit.

Foreman to Witness Tests.—When boilers are being tested by hydrostatic pressure the foreman of the shop having under his charge the repairs of boilers, or an authorized competent boiler maker, shall personally attend and assist the inspector in his examination.

Repairs and Steam Test.—When all necessary repairs have been completed, the boiler shall be fired up and the steam pressure raised to not less than the allowed working pressure.

STAY-BOLT TESTING.

Time of Testing Rigid Bolts.—All stay-bolts should be tested at least once every month, and no boiler must be used over three months under any circumstances unless thorough stay-bolt inspection has been made. Stay-bolts shall also be tested immediately after every hydrostatic test.

Method of Testing Rigid Bolts.—The inspector must tap each bolt from the fire-box side and judge from the sound or the vibration of the sheet which of them are broken. If stay-bolt tests are made when the boiler is filled with water there must be not less than 50 pounds pressure on the boiler. This will produce sufficient strain upon the stay-bolts to cause the separation of the parts of the broken ones. Should the boiler not be under pressure the test may be made after draining all the water from the boiler, in which case the vibration of the sheet will indicate any unsoundness. The latter test is preferable.

Method of Testing Flexible Stay-Bolts.—All flexible stay-bolts having caps over the outer ends shall have the caps removed at least once every year, and also whenever the inspector considers the removal desirable in order to thoroughly inspect the stay-bolts. The fire-box sheets should be examined carefully at least once a month to detect any bulging or indications of broken stay-bolts.

Broken Stay-Bolts.—No boiler must be allowed to remain in service when there are two adjacent stay-bolts broken in any part of the fire-box or combustion chamber, nor when three or more are broken in a circle 4 feet in diameter.

Tell-Tale Holes.—All stay-bolts shorter than 8 inches applied after Sept. 1, 1907, except flexible bolts, shall have tell-tale holes 3/16 inch diameter by 1¼ inches or more in the outer end. These holes must be kept open at all times, and must not in any case be plugged. All stay-bolts shorter than 8 inches, except flexible bolts, shall be drilled when the locomotive is in the shop for heavy repairs or at other suitable opportunity, and this work must be completed prior to Jan. 1, 1909.*

STEAM GAGES.

Location of Gage.—Every boiler shall have at least one steam gage which will correctly indicate the working pressure. Care must be taken to locate the gage so that it will be kept reasonably cool, particularly in case of gages located on the back head of boilers.

* Applications from companies desiring to omit the use of tell-tale holes will be considered when it can be shown to the satisfaction of the commission that unusual care is used in stay-bolt testing, both as to the frequency of tests and the selection of inspectors.

Siphon.—Every gage shall have a siphon of ample capacity to prevent steam entering the gage. The pipe connection shall enter the boiler shell direct, and shall be maintained steam tight between siphon and gage.

Time of Testing.—Steam gages should be tested at least once every month, and no boiler must be used over three months under any circumstances unless a thorough test has been made of the steam gage.

SAFETY VALVES.

Number and Capacity.—Every boiler shall be equipped with at least two safety valves, the capacity of which shall be sufficient to prevent, under any conditions of service, an accumulation of pressure of more than 5 percent above the allowed steam pressure.

Setting of Valves.—Safety valves shall be set by the gage employed upon the boiler to pop at pressures not exceeding 5 pounds above the allowed steam pressure, the gage in all cases to be tested before the safety valves are set or any change made in the setting. When setting safety valves the water level in the boiler must not be above the highest gage cock.

Time of Testing.—Safety valves should be tested under steam at least once in every month, and no boiler must be used over three months under any circumstances unless the safety valves have been thoroughly tested.

WATER GLASS AND GAGE COCKS.

Number and Location.—Every boiler shall be equipped with at least one water glass and three gage cocks. The lowest gage cock and the lowest reading of the water glass shall not be less than 3 inches above the highest part of the crown sheet.

Water Glass Valves.—All water glasses shall be supplied with two valves or shut off cocks, one at the upper and one at the lower connection to the boiler, and also a drain cock, so constructed and located that they can be easily opened and closed by hand.

Time of Cleaning.—All gage cocks and water-glass cocks shall be removed and cleaned of scale and sediment whenever the boiler is washed.

PLUGS IN FIRE TUBES.

Plugs Prohibited.—No boiler shall remain in service which has one or more fire tubes plugged at both ends of the tube unless the plugs are securely tied together by means of a rod not less than ⅝ inch diameter.

WASHING BOILERS.

Time of Washing.—All boilers shall be thoroughly washed not less frequently than once in thirty days.

Plugs to be Removed.—When boilers are washed all washout arch and water bar plugs must be removed.

Water Tubes.—Special attention must be given the arch and water bar tubes to see that they are free from scale and sediment.

Office Record.—An accurate record of all locomotive boiler washouts shall be kept in the office of the railroad company. The following information must be entered on the day that the boiler is washed:

(1) Number of locomotive.

(2) Date of washout.

(3) Statement that boiler was washed.

(4) Signature of the boiler washer or the boiler inspector.

(5) Statement that gage cocks and water glass cocks were removed and cleaned.

(6) Signature of the boiler inspector or the employee who removed and cleaned the cocks.

STEAM LEAKS.

Leaks Under Lagging.—If a serious leak develops under the lagging an examination must be made and the leak located. If the leak is found to be due to a crack in the shell or to any other defect which may reduce safety, the boiler must be taken out of service at once and thoroughly repaired before it is reported to be in satisfactory condition.

A certain form of specification card is provided on which the results of all calculations made in determining the working pressure and all necessary data shall be filed at the office of the public service commission. The calculations which must be made include the maximum stresses at the allowed working pressure for the following parts of the boiler: The stay-bolts at both the root of the thread and the reduced section; the crown stays or crown bar rivets at the root of the thread or smallest section at both the top and bottom of the bar; all round and rectangular braces, and the gusset braces. Also the shearing stress on the rivets and the tension stress on the net section of the plate in the longitudinal seam of lowest efficiency must be computed and duly recorded on the specification card. When accurate drawings of the boiler are available the data for the specification card may be taken from the drawings, but where such drawings are not available the required data must be obtained at the first opportunity when general repairs are made or when flues are removed. A regular certificate of inspection must be filed with the public service commission within ten days after each quarterly inspection.

Regarding the care of steam locomotives the laws provide that the boilers of all locomotives owned by corporations operating steam railroads within the State shall be washed out as often as once every thirty days, also that each boiler must be equipped with a water glass showing the height of the water in the boiler, the glass to be provided with two valves or shut-off cocks, one at each end, which may be easily opened or closed by hand. All such valves and gage cocks must be maintained in good condition and cleaned whenever the boiler is washed out. All steam valves, cocks and joints, studs, bolts and seams must be kept in such repair that they will not at any time emit steam in front of the engineer so as to obscure his vision. If it is found at any time by regular inspection or test that a boiler is unsafe for use, it must not be used again until it is repaired and made safe so as to comply with these regulations.

A suitable inspector of locomotive boilers is to be retained by the public service commission at a salary not to exceed $3,000 a year, whose duties shall be to inspect under the direction of the commission the boilers or locomotives used by any railroad corporation operating railroads within the State. He may cause the same to be tested by hydrostatic test, and shall perform such other duties in connection with the inspections and tests as the commission shall direct. This does not, however, relieve the railroad corporations from the duties of inspection imposed by the preceding regulations.

The apprentice school of mechanics of the New York Central Railroad at Indianapolis, Ind., has just closed its first year. The company has nine such schools along its system, the others being at Collinwood, Depew, Elkhart, East Buffalo, Jackson, McKees Rocks, Oswego and West Albany. The list of trades taught comprises machinist, boiler maker, blacksmith, tin and copper worker, pattern maker, molder, car maker, carpenter and cabinet maker. The pupils are paid 10 cents an hour the first year, 12 cents the first half of the second year, 14 cents for the last half, 16 cents for the first half of the third year, 18 cents for the last half, and 20 cents for the fourth and last year.

The schools are operated for ten and one-half months each year, two hours each day, three days in the week. A diploma is given each apprentice who completes the course, and his wages thereafter is to be 32 cents an hour. The nine schools during the year past had over 400 pupils, and the wages paid, not including the cost of instruction, amounted to $17,000.

Layout of a Taper Transit Piece.

Connection Between Two Round Cylinders th Taper Being Eccentric and One Side a Flat Surface.

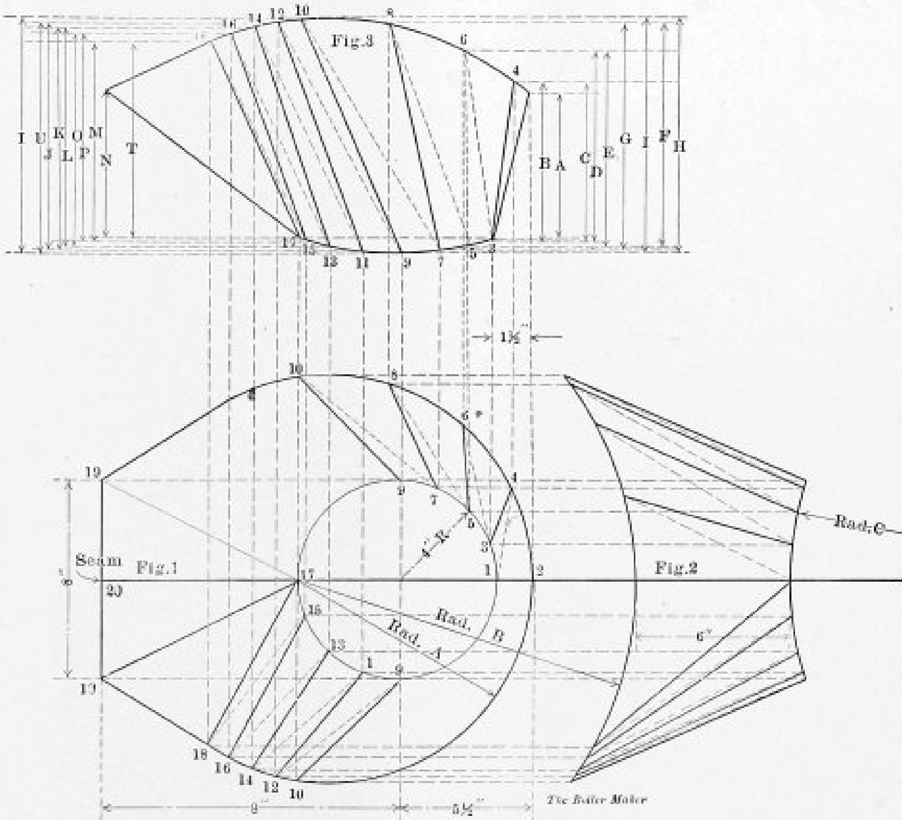
BY H. S. JEFFERY.

This particular layout will probably never come up in ordinary boiler work, but might accidentally turn up on some classes of sheet iron work. The problem is a difficult one, involving the use of triangulation, and, therefore, has not been written for the "infant" class in laying out, but is submitted more especially to the readers of The Boiler Maker who have had considerable experience in laying out by triangulation. The problem serves to show the importance of the method of triangulation as a means for laying out irregular shaped objects.

First draw Fig. 1, which is a plan view of the transit piece. The plan view of the bottom of the connection is a circle 8 inches in diameter. The plan view of the upper edge of the connection is irregular, one part being a semi-circle, whose radius is *A*, and the rest being formed of straight lines in the order shown in Fig. 1. In order to get a complete idea of how the connection is shaped it is necessary to draw two other views, Figs. 2 and 3.

To draw Fig. 2 it is necessary to know the diameters of the two cylinders which this transit piece connects. The radii *B* and *C* represent the respective radii of the two cylinders, and it will be noted that the height of the connection or distance between the cylinders is 6 inches. The outline of Fig. 2 is completed by projecting points from Fig. 1 to the arcs of the circles which were drawn with these radii in Fig. 2.

Fig. 3 is obtained in a similar manner, projecting the various points from Fig. 1 and taking the height of each point from Fig. 2. The camber lines at the top and bottom, Fig. 3, are irregular, and their development must be obtained by projecting lines from Fig. 1 to corresponding points on Figs. 2 and 3. The most convenient way to obtain this development is to divide the semi-circle whose radius is *A*, Fig. 1, into a number of equal spaces and also to divide one-half the circle whose radius is 4 inches, Fig. 1, into the same number of equal spaces. As shown in the figure the points are numbered from 1 to 20. It will be noticed that on the circle whose radius is *A*, Fig. 1, the spaces have a different pitch after the center line is passed, which is due to the fact that after point 10 has been passed the semi-circle is completed, and the balance of the curved surface, from 10 to 18, which is a much shorter distance than the distance from 2 to 10, must be divided into the same number of spaces as the quarter circle. 2-10. This, of



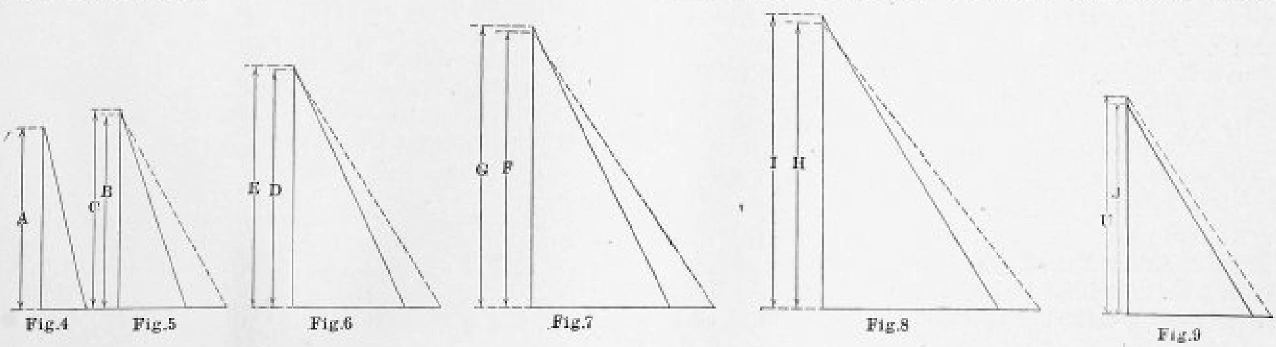


Fig.4 Fig.5 Fig.6 Fig.7 Fig.8 Fig.9

course, makes the spaces smaller. Figs. 1, 2 and 3 must be drawn very neatly and accurately, as the number of lines confuses the figure and makes it an easy matter to make a slight mistake, which would mean the ruin of the whole pattern.

Before attempting to obtain the true length of the lines which form the triangles by which the pattern is to be developed, it might be stated that for the sake of conveniently laying out this article the object could be divided into two parts as follows: Fig. 9-10-2-10-9-1-9 forming one pattern and 9-10-19-20-19-10-9-17-9 forming the other. This would require, however, two different patterns, and, although one of them would form a very simple layout the other would be quite complicated. Since the object is symmetrical on both sides of the horizontal center line, Fig. 1, it would be easier to lay out the pattern for that part of the object on one side of this line, since this pattern would then answer for the other half.

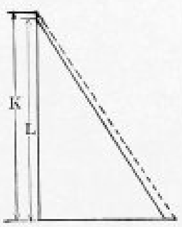


Fig. 10

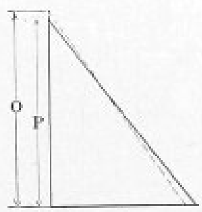


Fig. 11

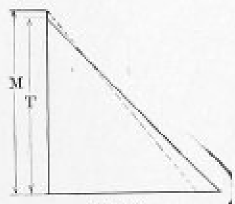


Fig. 12

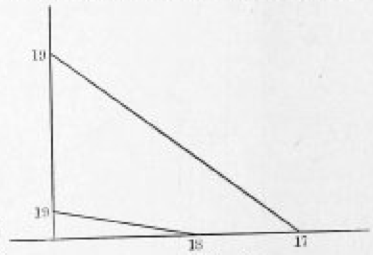


Fig. 13

Divide the surface of the connection into triangles, as shown by the solid and dotted lines, Figs. 1, 2 and 3. To obtain the true length of these lines proceed as follows: Draw the vertical line *A*, Fig. 4, equal in length to *A*, Fig. 3. At right angles to this vertical line draw a horizontal line of any length, and setting the dividers to the distance 1-2 on the solid line, Fig. 1, with the intersection of the vertical and horizontal lines, Fig. 4, as a center, draw an arc cutting the horizontal line. The hypotenuse of this triangle is then the true length of the line 1-2. In Fig. 5 make the altitude *B* equal to *B*, Fig. 3. Set the dividers to the distance of the dotted line 1-4, Fig. 1, and using the intersection of the vertical and horizontal lines, Fig. 5, for the center draw an arc, cutting the horizontal line. The hypotenuse of this triangle is then the true length of the dotted line 1-4. Also on Fig. 5 make the altitude *C* equal to the distance *C*, Fig. 3. Take the distance of the solid line, 3-4, Fig. 1, and using the intersection of the vertical and horizontal lines, Fig. 5, as a center draw an arc cutting the horizontal line. The hypotenuse of this triangle is then the true length of the line 3-4. In a similar manner construct Figs. 6, 7, 8, 9, 10, 11 and 12, in order to get the true lengths of the lines 3-6, 6-5, 5-8, 8-7, 7-10, 10-9, 9-12, etc., taking the proper heights from Fig. 3 and the corresponding horizontal distances from Fig. 1. Fig. 12 gives us the true length of lines 15-18 and 18-17. The true length of 17-19 and 18-19 is given by Fig. 13. in which *N*,

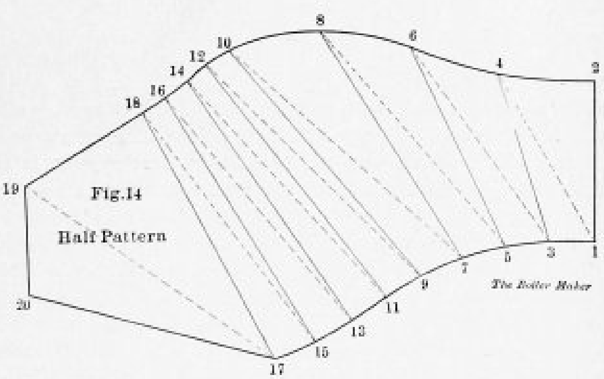


Fig. 14
Half Pattern

Fig. 3, has been laid off as the height, and 17-19, Fig. 1, has been laid off as the horizontal distance. The true length of 17-20 is shown directly on Fig. 3. Likewise the true length of the line 19-20 is shown in the end elevation, Fig. 2. It will be seen that really this line should be the arc of a circle, radius *B*. In the pattern, however, it has been assumed to be a straight line in order to avoid confusing the figure. For an exact fit it should, of course, curve outward slightly.

We are now ready to develop Fig. 14. Take two pairs of dividers, setting one pair to the distance between points 2 and 4 on the large circle, Fig. 1, and the other to the distance between the points 1 and 3 on the small circle, Fig. 1. Draw the solid line 1-2, Fig. 14, equal in length to the solid line 1-2, Fig. 4. Step off with the dividers one large space at the top and one small space at the bottom. Take the length of the dotted line, Fig. 5, and using 1, Fig. 14, as a center draw an arc at the top intersecting the arc previously drawn, locating point 4. Then with the length of the solid line, Fig. 5, using 4 as a center, draw an arc at the bottom, intersecting the arc previously drawn, locating the point 3. Step off another space with the dividers from the points 4 and 3. Take the length of the dotted line, Fig. 6, and using 3, Fig. 14, as a center, draw an arc at the point 6, intersecting the arc previously drawn. Then with 6 as a center and with the length of the solid line from Fig. 6, draw an arc at the point 5, intersecting the arc previously drawn. Step off another space at both top and bottom and proceed in a similar manner until points 10 at the top and 9 at the bottom are reached.

It is now necessary to alter the pitch of the dividers, which were set for the large spaces at the top of the pattern. They should now be set to the distance between the points 10 and 12, Fig. 1. Then step off a space at the top and bottom of the pattern, as before, and taking the true length of the lines which form the triangles in Figs. 9, 10, 11, 12 and 13, construct this portion of the pattern in a similar manner as before, until the points 18 at the top and 17 at the bottom are reached.

To develop the remainder of the pattern set the trams to the true length of the line 18-19, as found in Fig. 13, and with point 18, Fig. 14, as a center draw an arc through the point 19. Set the trams to the true length of the line 17-19, as found in Fig. 13, and with point 17, Fig. 14, as a center, draw an arc intersecting the arc previously drawn at point 19. With the trams set to the distance 19-20, as measured from Fig. 2, draw an arc through the point 20, Fig. 14, using point 19 as a center. Then with the trams set to the distance 17-20, as measured directly from Fig. 3, and with point 17, Fig. 14, as a center, draw an arc intersecting the arc previously drawn at point 20. This completes the outline of the pattern. The laps and allowances which must be made, due to bending the material, must, of course, be added outside of these lines.

A large attendance is expected at the nineteenth annual convention of the Boiler Manufacturers' Association, which is to be held at the Piedmont Hotel, Atlanta, Ga., Oct. 8, 9 and 10. A very fine programme has been prepared and unusual interest is being taken in the meeting.

A Large Hydraulic Flanging Press.

BY E. A. DIXIE.

In the boiler shop of the Juniata shops of the Pennsylvania Railroad, at Altoona, Pa., some remarkable flanging work is done on a large hydraulic press, built for them by the Niles-Bement-Pond Company, of Philadelphia, Pa. As a general proposition, this boiler shop handles all press work of a similar nature for the whole system, and it has a capacity for turning out one new boiler and one new tender for each working day.

Formerly all flanging was done by hand. The work was tedious and difficult and injured the plates, as hammering on partly cooled plates is very apt to crystallize them. Machine flanging takes a fraction of the time, and the plate is handled at the most suitable heat. Further, the machine flanging results in uniform work, uniform in shape and also in thickness, leaving no thinned parts such as are produced by excessive hammering in one place. Also the product is interchangeable and can be shipped to distant points with the assurance that it will fit.

The press itself, with a pair of dies in place, is shown in Fig. 1. To the left is the furnace for heating the plates. This furnace is fired with gas. The small press at the left is also used for flanging work within its capacity.

The bed of the large press measures 12 feet by 7 feet 2½ inches. The table can be elevated 6 feet. The main table or ram has a stroke of 48 inches, and exerts a pressure of 700 tons. Within the main table is a center ram having the same stroke and capable of 200 tons pressure. Four, so called, vise rams are equally spaced around the main table. These are used to clamp the work, the same as holders in drawing operations; they exert a pressure up to 50 tons each. The top ram is movable and of 100 tons capacity.

To the extreme right in Fig. 1, in front of the column at the wall, is the male die for forming the dome shown in the foreground in Fig. 2. In the past, domes have been made in various ways. Formerly they were made in three pieces, as shown in Fig. 7. Some time ago the top pieces were made of steel castings, but that shown in Fig. 7 is press work, made from fire-box steel. The castings from which these top pieces were made cost about $18 each in the rough. The pressed-steel top piece costs, labor and material, about $8, and is superior to the casting in every way. The center piece of the old style dome is boiler plate. The lower dome flange shown in Fig. 7 is fire-box steel pressed to shape.

The large dome shown in Fig. 2 was made as an experiment to see what could be done in the way of making high or deep draws. The original plate of fire-box steel was 1⅛ inches thick and 69 inches in diameter, with a 2⅛-inch hole in the center. The plate was heated to about 1,400 degrees, as this was found to be the most suitable heat. Plates previously heated as high as 1,800 degrees were apt to draw thin or stretch unevenly. The hole in the middle of the plate is used to center it.

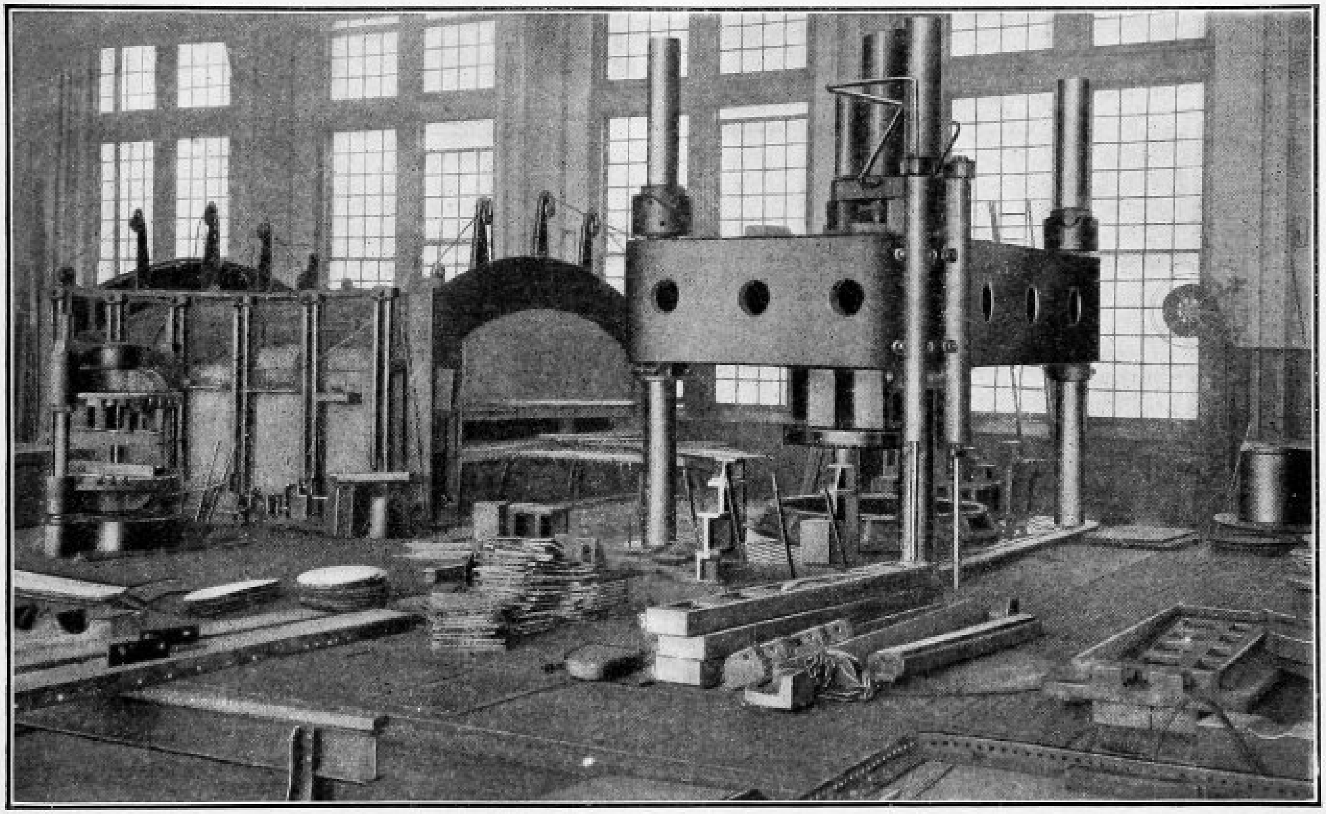


FIG. 1.—THE LARGE FLANGING PRESS.

In Fig. 3 is shown the method of drawing up these domes. *A* is the plate centered on the lower punch *B* by the projection *G'*. *C* is the die. *D* is the holder plate supported on four hydraulic holder rams under a pressure of 28 tons each. *B* is secured to the center ram, having a capacity of 200 tons pressure. The punch *B* is slightly tapered so as to be readily removable from the drawn dome, the taper being 1 inch in 30 inches. *H* is the upper table of the press.

The dome shown in Fig. 2 is 30 inches diameter by 25 inches high, and is drawn up to this size in four heats. The flange at this state is about 55 inches diameter; about half way between crown and flange the sides are reduced from 1⅛ down to ¾ inch in thickness. The dome goes to the machine shop next, where it is put on a boring mill and the flange is turned on the edge to size and beveled to a calking edge. It then goes back to the flanging machine, where another heat and press operation shapes it to the barrel of the boiler. A dome 16 inches high, 30 inches inside diameter is made from a round blank of fire-box steel 64 inches diameter by 1⅛ inches thick. The dome is pressed up in three heats, then turned on the flange, and a final heat and press operation brings it to the curvature of the boiler barrel. The standard flange is 52 inches diameter finished.

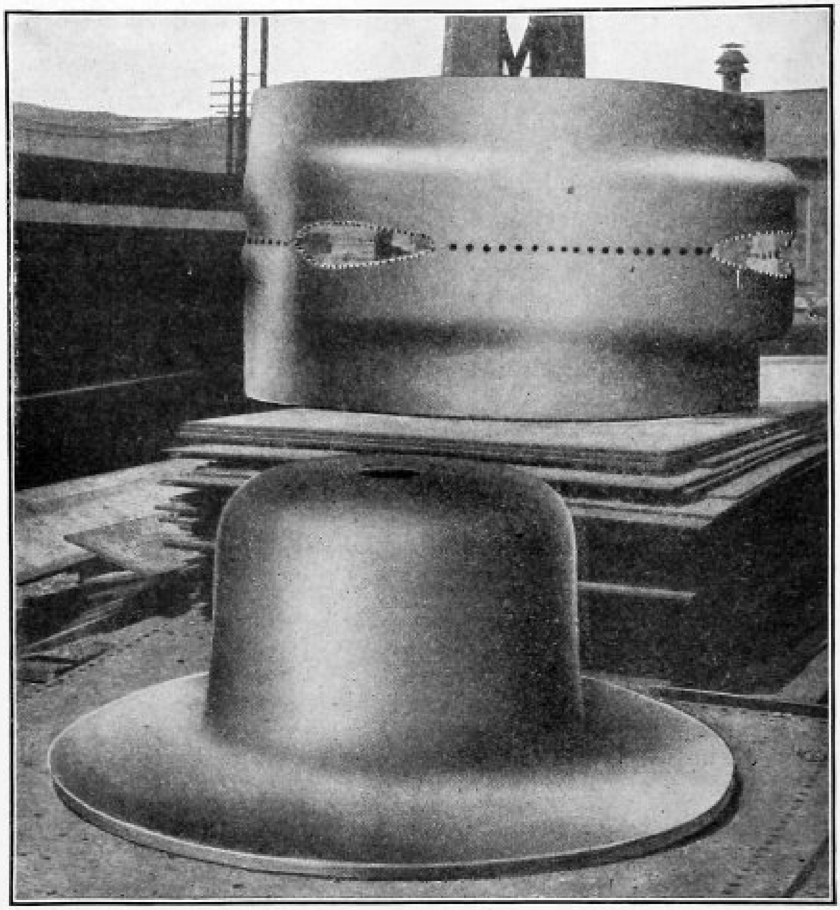


FIG. 2.—FLANGED DOME AND HIP SHEETS.

HIP SHEETS.

Hip sheets were of course formerly flanged by hand. A flanging squad for this job consisted of one flanger and four helpers. The time consumed was about 10 hours. The result was not to be compared in quality with the machine-flanged plate. The first attempts at machine flanging hip sheets were naturally on one sheet, the same as in hand flanging. It was later decided to try flanging two sheets at the same time.

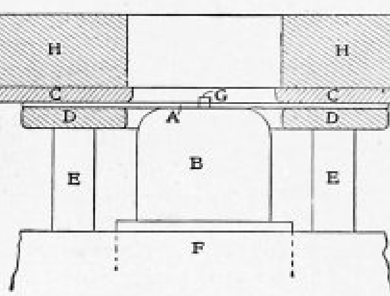


FIG. 3.—DIES FOR FLANGING DOMES.

But before trying it on a steel sheet, a small pair of model dies was made and, using a piece of sheet lead, the sheet was forced up to the desired shape. With this model it was easy to measure the amount of stretch that had taken place at various points, and possible to take precautions to prevent the plate from drawing thin. The precautions taken in this direction are plainly shown in the half-tones, Figs. 2 and 5, and in the line cut, Fig. 4.

The depth of draw, where the gap in the plate is, varies from 6 to 7 inches, according to the type of boiler the hip sheet is intended for. That shown is for a *E. 3 A.* standard Atlantic type passenger engine.

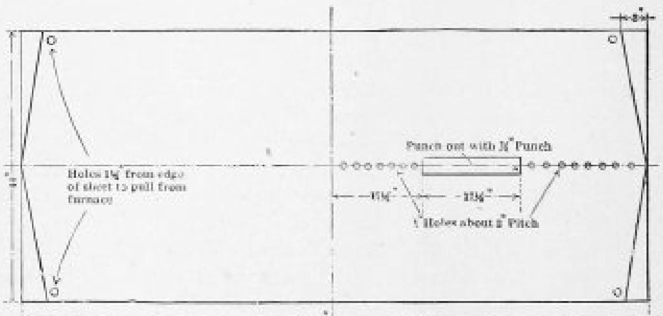


FIG. 4.—LAYOUT OF HIP SHEETS.

The plate is laid out as shown in Fig. 4. The holes are punched as indicated. The greatest strain comes of course at the deepest draw; that part is for a certain distance punched with the holes meeting one another. When the dies come

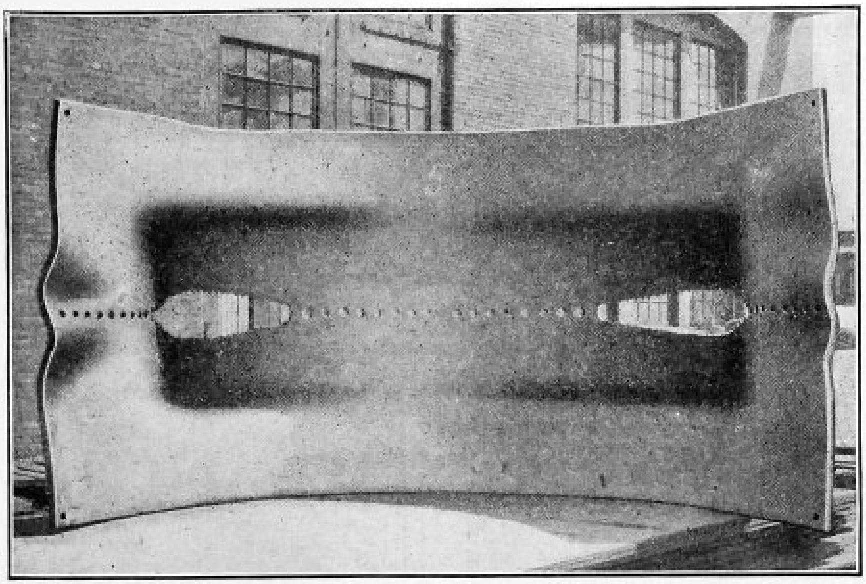


FIG. 5.—HIP SHEETS.

together, the plate at this point offers little resistance, and the metal is not stretched or thinned but the plate draws open at the gap.

The machine-made hip sheets are made in pairs. The squad consists of four men instead of five, and a pair of hip sheets is made in about half an hour, or a hip sheet every 15 minutes, instead of every 10 hours as when made by hand. In the machine-made hip sheet there is about 200 pounds less material than in the hand-made one. In Fig. 6, to the left, a hip sheet is shown with rivet holes in it ready for putting into the boiler. The forming of these sheets is done at one heat. The material is fire-box steel and varies for the different types of boilers from 9-16 to 15-16 inch thick.

TUBE AND DOOR SHEETS.

Tube sheets were formerly hand-flanged and took about 5 hours to finish. They are made of fire-box steel ½ inch thick. It takes about 30 minutes to flange them in the machine. Door sheets are also made of fire-box steel, but they are only ⅜ inch thick. Where the doors are oval or round, the flanging is all done in the machine, but rectangular doors are hand-flanged, as it is difficult with this shape of door to prevent tearing the plate when machine-flanging.

THROAT SHEETS.

The material for throat sheets is shaped as shown in the line cut, Fig. 9. Close to the upper corners at *A* will be seen two half-round notches. When the sheet is laid in the dies, these notches bear against braces to prevent the plate being pulled by the dies as they come together. Throat sheets took 20 hours to flange by hand; the job is now done in about 40 minutes.

In Fig. 6 are shown a hip, a throat and a tube sheet ready for assembling.

Figs. 7 and 8 show two views of a partly completed *E. 3. A.* standard Atlantic type passenger engine. In Fig. 7 the old style three-piece dome is shown, also the position of the hip sheet where it joins the roof sheet. In Fig. 8 the position of the throat sheet is shown. This is rather an uncommon view, as it shows the roof-sheet boxes and back head channels for fastening the head stays.

The dies are piled up in the yard in front of the boiler

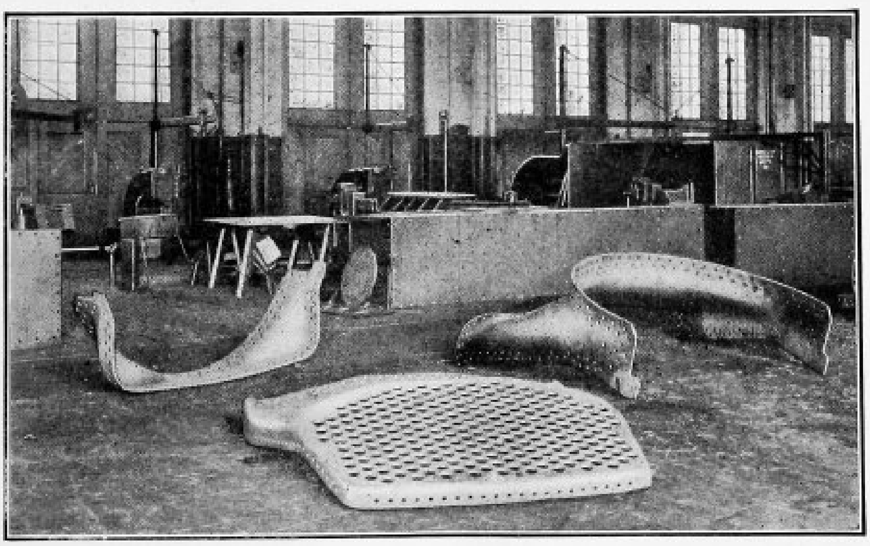


FIG. 6.—TUBE, HIP AND THROAT SHEETS, STANDARD ATLANTIC TYPE PASSENGER ENGINE.

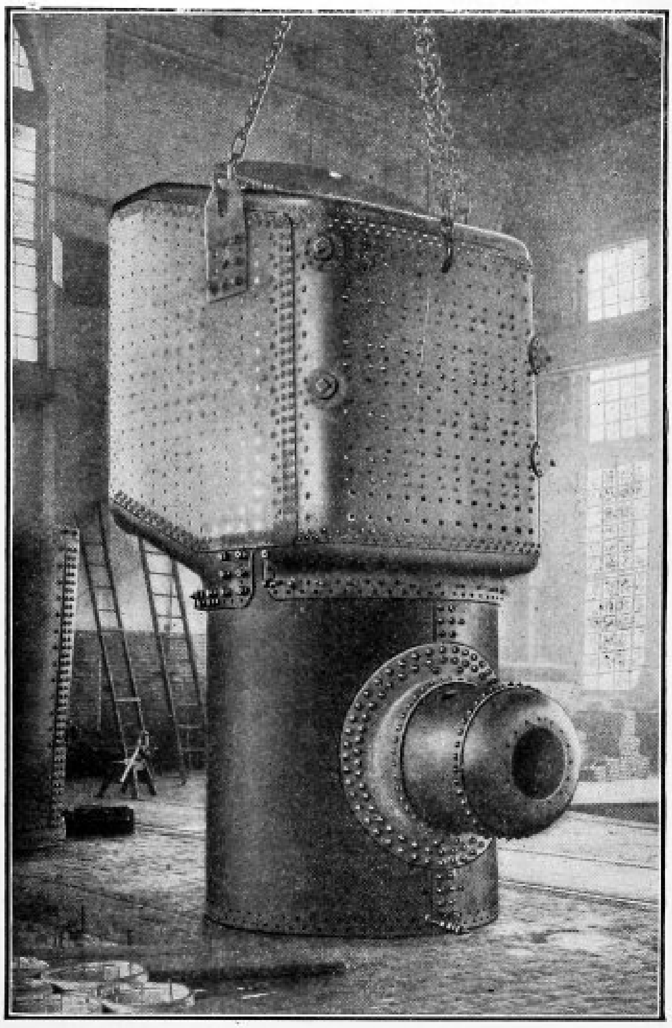


FIG. 7.—PARTLY FINISHED BOILER.

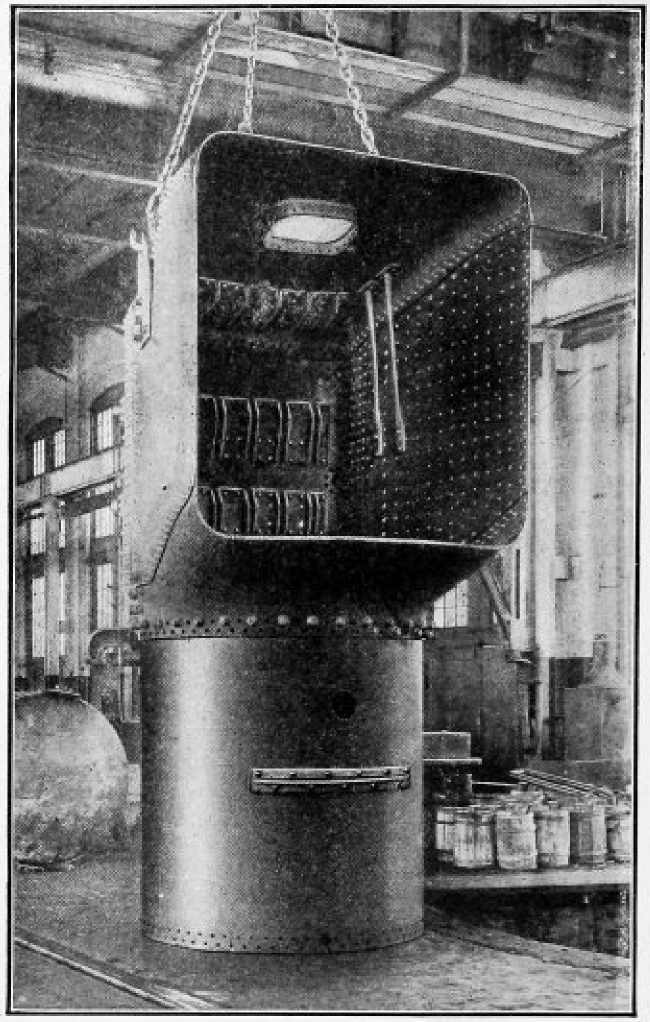


FIG. 8.—INTERIOR VIEW OF PARTLY FINISHED BOILER.

shop, which has a large swinging door through which an overhead traveling crane may be run out into the yard for dies or material. The average time necessary to build a locomotive boiler in this shop is 15 days, and for a new type about 30 days, a record for speed which could not be attained if it

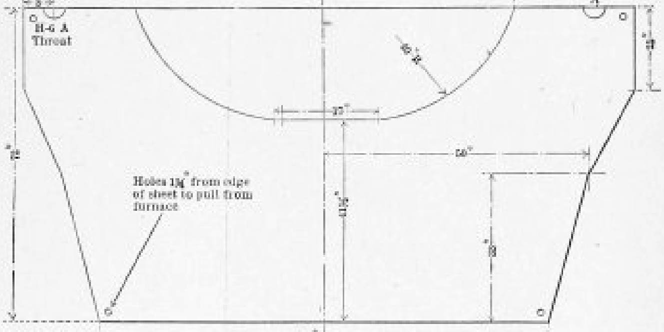


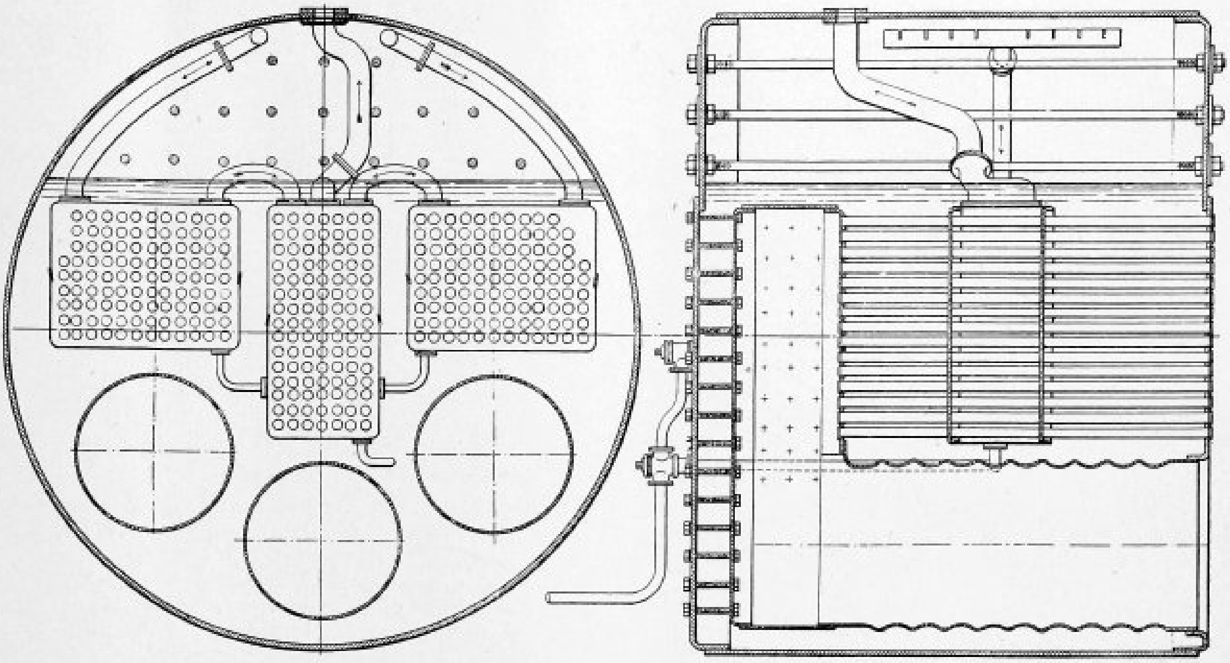
FIG. 9.—LAYOUT OF THROAT SHEET.

were necessary to do all flanging by hand. Machine flanging has made it possible not only to turn out work in quicker time but also to turn out a uniform and reliable class of work.—*American Machinist.*

Superheated Steam from Scotch Boilers.

Some interesting data regarding the use of superheaters with Scotch marine boilers has been recently brought out in the case of the two French cargo steamers *La Rance* and *Garonne*. Both ships were built by the Société Anonyme des Chantiers de St. Nazaire for the Compagnie Générale Trans-Atlantique, and are of exactly the same dimensions, the length being 299 feet, breadth 40 feet and load draft 21 feet. The propelling machinery in each case is a three-cylinder vertical triple-expansion engine, supplied with steam by two Scotch boilers equipped with Howden's system of forced draft. The boilers on *La Rance*, however, are provided with Pielock superheaters, as shown in the detailed drawings of the boiler.

The Pielock superheater consists of rectangular box-like compartments, built around each nest of tubes in the boiler. Dished plates are used in the construction, and these are surrounded by two bent plates, forming the casing, which is .78 inch in thickness. The dished plates, or heads, are .39 inch thick. As the boilers on *La Rance* have three furnaces each, connected to three separate combustion chambers, there are, of course, three superheating compartments in each boiler, one for each nest of tubes. Steam is taken from two dry pipes, located at the top of the steam space in the shell, and is led to the superheaters over the two side furnaces, and from there into the middle compartment, whence the main steam pipe leads



LONGITUDINAL AND CROSS-SECTIONS OF "LA RANCE" BOILERS, SHOWING SUPERHEATER BOXES.

directly from the boiler. Drain pipes are provided at the bottom of the superheating compartments, so that they may be flooded if necessary when raising steam. The Pielock superheaters raise the temperature of the steam from 393 to 752 degrees F., or about 200 degrees C.

The boilers of the *La Rance* have a heating surface of 3.760 square feet, and a total grate area of 90.4 square feet, the superheating surface being 786 square feet. The ratio of net heating surface to grate surface is 41.6 to 1, and of gross heating surface 50.3 to 1. Lap-welded tubes of mild Siemens-Martin steel are used, and boiler plates of the same material of 23 percent elongation and a breaking strain of 62,000 to 71,000 pounds per square inch.

As both these ships are similar in all details except in the matter of superheating the steam, their performance gives a good opportunity to demonstrate the value of superheated steam. Tests showed that in the case of *La Rance*, where the steam was superheated 200 degrees C., there was an increase of power of 18 percent and a decrease of steam consumption of 20 percent. The coal consumption of *La Rance*, using superheated steam, was .9 pound per horsepower-hour, while on the *Garonne* the coal consumption was found to average 1.126 pounds per horsepower-hour.

A Quick Method for Laying Out an Angle of a Cylinder

BY JAMES CROMBIE.

This is for the man in the shop; the fellow who does not know anything about projection, orthographic or otherwise. He will require only a scale and chalkline to do the job. First, measure off the plate to the circumference required to make the cylinder or pipe, then lay off the length required for the elbow, as *A-B*, Fig. 1, and divide the circumference into eight equal parts as in Fig. 2. The top of the curve will be on the line 1-5-1, Fig. 2; 3-3 will be one-half the length, while 2-2 and 4-4 will each be one-seventh the length. Assuming that the length at *A-B* is 9 inches, then one-half of 9 is 4½ inches, the length required at 3-3. One-seventh of 9 is 1 9/32 inches, or the length required at 2-4-4-2. A curve drawn through these points locates the miter edge of the plate. The writer has employed this method for a number of years, and has found it much quicker than other methods, as it saves a lot of drawing.

In squaring off the end of the plate it sometimes happens that neither compass, trammels or square are handy. The rule is $C = \sqrt{A^2 + B^2}$ where C is the hypotenuse of a right-angled

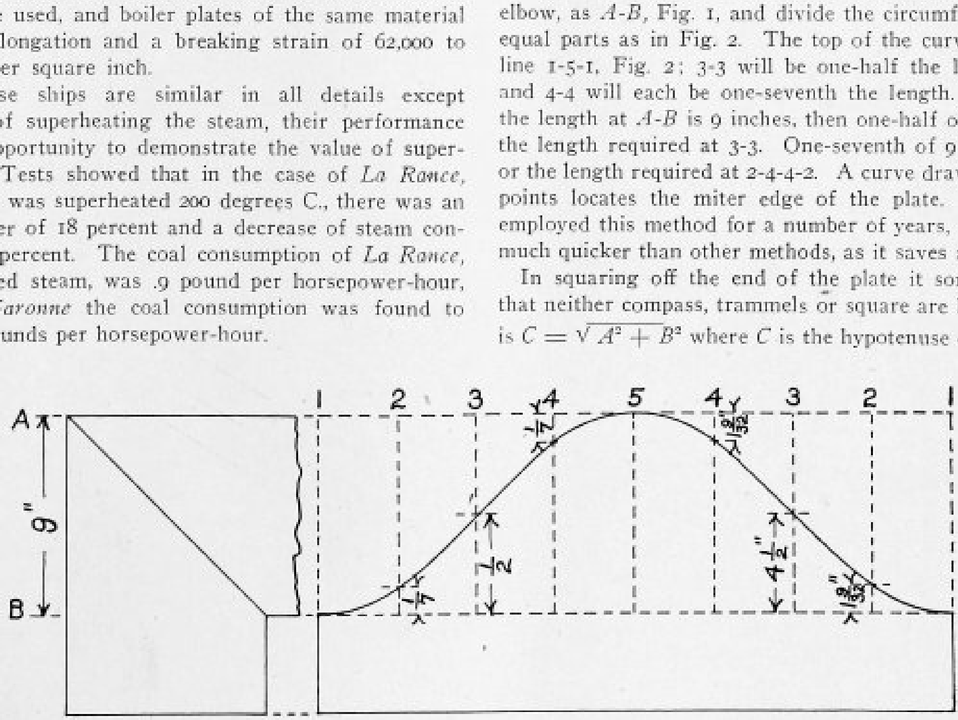
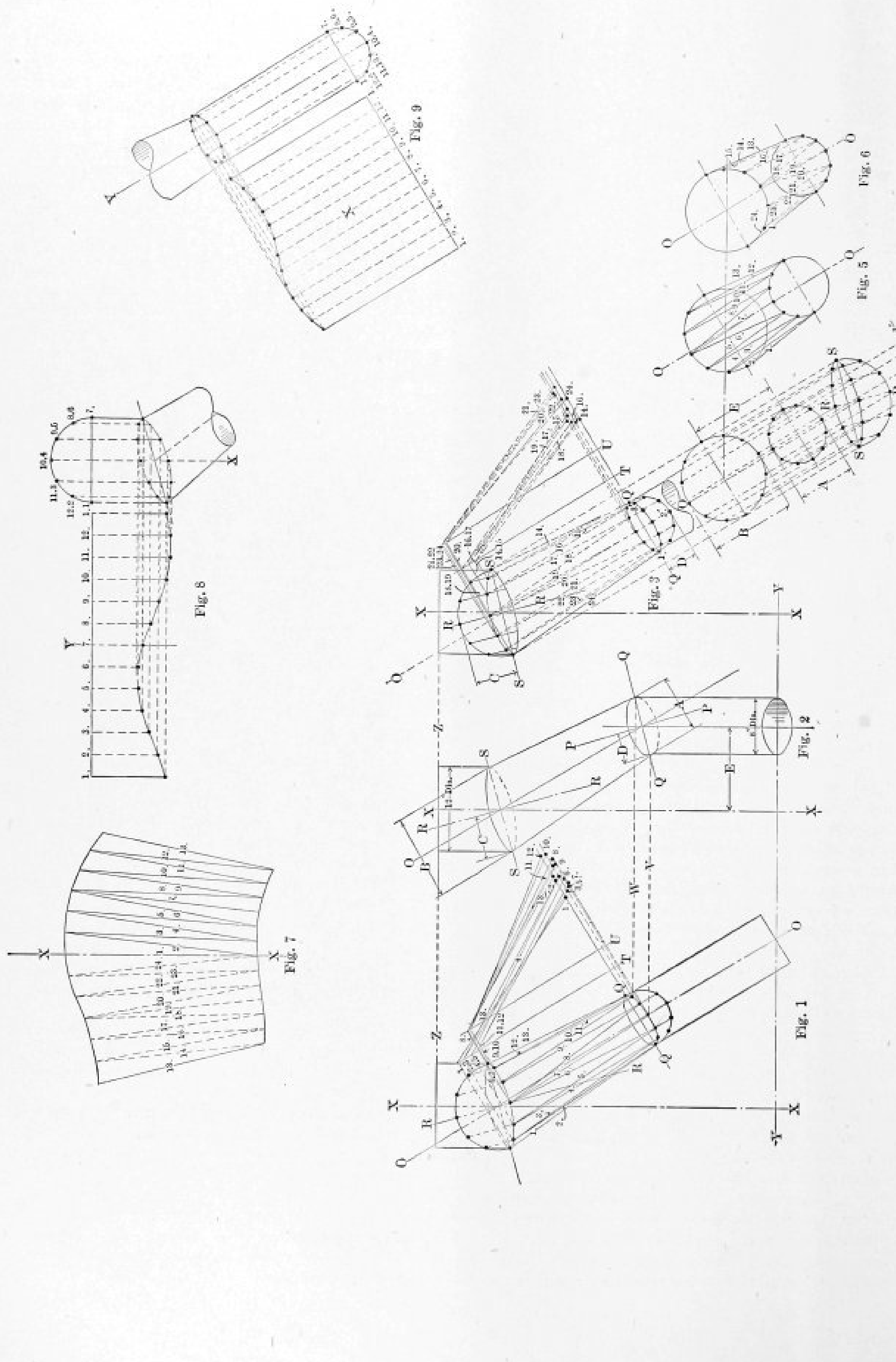


FIG. 1. FIG. 2.

DIAGRAM FOR LAYING OUT AN ANGLE OF A CYLINDER.



PATTERNS OF A DOUBLE-OFFSET PIPE, SHOWING METHOD OF DEVELOPMENT.

triangle, whose legs or sides are *A* and *B*, respectively, but it is much easier to remember the figures 3, 4, 5 and to square your plate by them. Just measure along one edge of the plate 3 feet and along the adjacent edge 4 feet. Then measure 5 feet between these points, completing the right-angled triangle and giving the square corner for your plate. Any multiple of the figures 3, 4, 5 may be used, as, for instance, multiplying by 4 we have 12 inches and 16 inches for the sides and 20 inches for the hypotenuse. These are simple things, but simple things promptly applied will often put your job through ahead of the other fellow, and that is what counts at the end of the day.

Layout of a Double Offset Pipe.

BY C. REYNOLDS.

In the layout of a double offset pipe be very accurate in all your measurements, so that the points of intersection will be exact as in the ellipses in Fig. 2, at *SS* and *QQ*, which are the lines of intersection. The first thing to do is to draw the base line *YY* in Figs. 1 and 2 long enough to accommodate two views, the side and front elevations; then erect two perpendiculars *XX*, Fig. 1, and *XX*, Fig. 2; mark the distance *E* on the base line from *X*, and erect another perpendicular. Mark the desired distance for the intersection of lines *Q*, *O* and *P* and the distance on *XX* from the base, where lines *X*, *O*, *R* and *S* meet; connect these two points as *OO* shown in Fig. 2; then draw a line at the apex parallel to the base line *YY*, as *ZZ* in Figs. 1, 2 and 3. In Fig. 1 mark the distance where *O* and *Y* meet; then the distance on *X* where *O*, *X* and *R* meet; by drawing the line *OO* from this point, cutting the base line where marked, we have all the center lines.

In developing this surface it is not absolutely necessary to draw the outlines in Figs. 3, 5 and 6, because the numbered lines can be placed in Figs. 4 and 1; nevertheless, this is a good way to avoid confusing the lines. Figs. 5 and 6 have the same outline as Fig. 4, and Fig. 3 is the same outline as Fig. 1. Develop half the opening and all of the intersection as shown in Fig. 3 at *SRSR* and 1, 2, 3 at both top and bottom of the middle section in Figs. 1 and 3.

To draw the lines of intersection it is necessary to have all the outlines. After doing this draw lines *V* and *W* from the outlines in Fig. 2 parallel to the base line, cutting the center line *OO* in Fig. 1. Having four points, now draw an ellipse, cutting all four points. Draw lines the same way at the large intersection, cutting the center line *XX*, and, using the center of the opening as a center, draw an arc cutting the line *RR*, and now having the four points, draw another ellipse. Divide the semi-developed openings *SRS* and 1, 2, 3 into any number of equal spaces; then draw lines square with the lines *SS* and *QQ* from those points, cutting the lines of intersection.

In Fig. 4, *E* is equal to the distance *E* in Fig. 2; *B* is equal to *B* in Fig. 2, and *A* is equal to *A* in Fig. 2.

The semi-developed opening and the points of intersection *SRSR* are the same as *SRSR* in Fig. 3; also the semi-developed opening at 1, 2, 3 is the same as that in Fig. 3 at 1, 2, 3. *D* in Fig. 3 is equal to *D* in Fig. 2, and *C* is equal to the *C* in Fig. 2. You can see in Fig. 4 the circle *B* and *A* are not divided into equal spaces; by following the dotted lines you can see the reason for this. After having all the points on circles *A* and *B*, we will look at Figs. 5 and 6. In this layout it is better to have all lines solid on one side and all dotted on the other. A great many people number their lines at each point of intersection, but I prefer numbering them as the drawing shows it. Draw all the lines and number them as in Figs. 5 and 6; having done this, draw lines to correspond with those just drawn in Figs. 1 and 3; then draw lines square with the center lines *OO* from the points of intersection at *QQ* and *SS*, as in Figs. 1 and 2.

Lines *T* and *U* are parallel to lines *OO*, and are used in getting the true lengths of the numbered lines in Figs. 5 and 6. Take the lengths of the lines in Fig. 5 from 1 to 7, and using *T* as the center, in Fig. 1, strike arcs on lines that correspond with that number; then take the length of those from 8 to 13, using *U* as the center, and strike arcs the same as before, also do the same in Fig. 3, using the lengths of the lines in Fig. 6. Having done this, connect the points on *T* and *U* with the points on the square lines below; these will then be the true lengths of the lines.

To develop the middle section, draw the line *XX* in Fig. 7; mark off on *XX* the true length of line No. 1; then at the top, using the top point as a center, strike two spaces equal to those on the semi-developed opening at *SRS* in Fig. 3 on either side; using the lower points on line 1 as center, strike an arc cutting the small arcs at the top, so the distance between the points will be equal to the line 2-4 on one side and the line 2 on the other; then using the same center strike two spaces, one on either side, equal to the spaces at 1, 2, 3 in Fig. 3. Use the upper end of line 2-4 as a center, strike the true lengths of line 2-3, and so on until the whole thing is complete.

To lay out the top section, draw a semi-circle the same size in diameter as the pipe, and divide this into any number of equal spaces. Draw lines parallel to line *X* in Fig. 8 from the points on the semi-circle cutting the intersection; then draw lines square with line *X* from the points on the intersection, long enough to accommodate the circumference of the pipe. This section is 12 inches in diameter. There are many ways of finding the circumference of a circle, but the best way and the one that is used most, is to multiply the diameter by 3.1416. It may be obtained in other ways as follows:

If $D =$ Diameter.
$C =$ Circumference.
$A =$ Area.
$\pi = 3.1416$.
$R =$ Radius.

Then

$$C = \pi D$$
$$C = 2\pi R$$
$$C = 2\sqrt{\pi A}$$
$$C = \frac{2A}{R}$$
$$C = \frac{4A}{D}$$

3.1416×12 inches $= 37.699$ or $37\frac{23}{32}$ inches circumference.

Mark one-half the circumference on either side of line *Y*; divide each half into as many equal spaces as the semi-circle was divided into; draw lines from these points parallel to lines *Y* and *X* until they cut the line that corresponds with it, as shown in the figure.

The lower section, Fig. 9, is laid out the same as Fig. 8, with the exception of the diameter and the circumference; the diameter is 8 inches, therefore, the circumference is $3.1416 \times 8 = 25.1328$, or $25\frac{1}{8}$ inches.

If you desire to have the top and bottom sections of the same diameter and the middle section to lap on the outside at the top and on the inside at the bottom, this layout will be the best and most accurate.

Fuel oil is coming into general use among the railroads of Mexico. The Mexican Central is now taking 4,000 barrels of fuel oil daily from the Mexican Petroleum Company.

Methods of Obtaining Flexibility in Locomotive Fire-Boxes.

The form and construction of a locomotive fire-box does not seem at first thought to be well adapted for resisting high pressures and rough service. As usually constructed, the fire-box consists of a rectangular shaped box of thin, flat plates, securely riveted to a solid frame, called the mud-ring, at the bottom, and stayed with rigid bolts spaced a few inches apart over its entire surface to the outside sheets of the boiler, which are much heavier and cooler than the fire-box sheets. As the fire-box sheets are subjected to a higher temperature than any other part of the boiler, they, of course, expand and contract a greater amount than the neighboring parts to which they are fastened or stayed when the boiler is alternately fired up and allowed to cool off. The effect of this unequal expansion, which is restrained by the rigid connections to the rest of the boiler, added to the stresses caused in the plate by the steam pressure and jar and shock, due to the weight of the water and other parts of the locomotive while in service, is to cause the sheets to bulge and crack between the points at which they are stayed, and to start leaks at the stay-bolts, tube ends and seams.

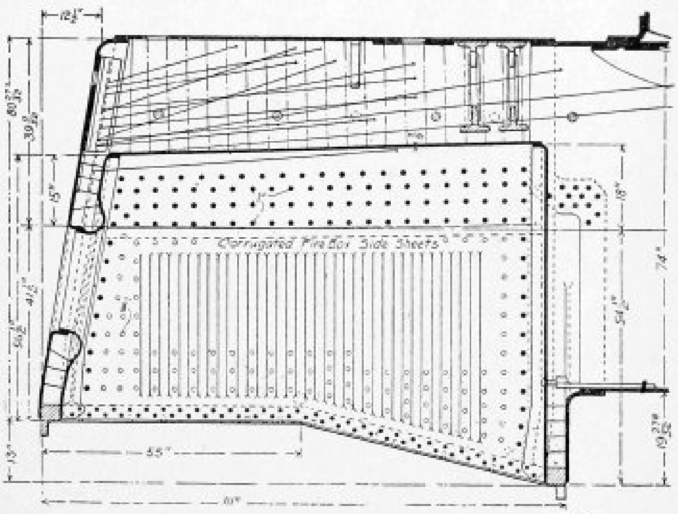


FIG. 1.—FIRE-BOX WITH CORRUGATED SIDE SHEETS AND O'CONNOR DOOR SHEET.

It does not seem practical to construct a locomotive fire-box in any other form, and so numerous attempts have been made to make the sheets themselves and their connection to the rest of the boiler as flexible as possible. If even a moderate amount of flexibility is obtained, the cost of repairs to the fire-box, stay-bolts and flues is greatly reduced. Some of the devices which have been most successful in producing flexibility are flexible stay-bolts, corrugated or cupped fire-box sheets, flexible mud-rings and expansion seams.

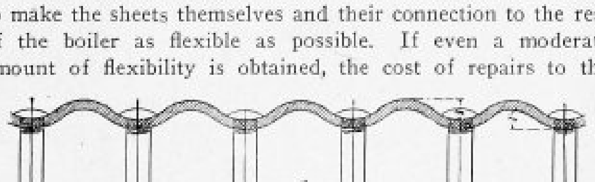


FIG. 2.—DETAILS OF CORRUGATED SIDE SHEET.

Flexible stay-bolts have done much to relieve this trouble, and their use has become quite general in modern locomotives. The most common form is that in which a ball and socket joint is used in the fastening at the outside sheet, the bolt being threaded and riveted to the fire-box sheet in the same manner as an ordinary rigid stay. The bolt is thus free to adapt its alinement to slight movements of the fire-box sheet without being subjected to a bending stress, such as is set up in a rigid bolt firmly fixed in the outside sheet. Flexible stay-bolts are usually installed in what is known as the "breaking zone," or in those parts of the fire-box where experience has shown that the greatest number of bolts are liable to break. There is a tendency now, however, to install flexible stays throughout the entire fire-box. Their use has not only greatly reduced the number of broken stay-bolts but has reduced the rigidity of the fire-box to such an extent that its length of service has been materially increased.

Cupped side sheets, in which the plates were pressed to form cups or depressions, concave on the fire side, about 3 inches diameter and ½ inch deep, were used about ten years ago on the Chicago, Rock Island & Pacific Railroad. Each stay-bolt was placed in the center of a cup so that its head was somewhat protected from the fire, while the elasticity, due to the cupping, was expected to give the metal free play and allow for the irregular movements of the fire-box sheet, due to temperature conditions. While this construction greatly reduced the breakage of stay-bolts it does not appear to have given permanent satisfaction and has since been discarded.

Corrugated side sheets, in which the corrugations are vertical, extending from a short distance below the center line of the boiler almost to the mud-ring, throughout the length of the sheet to within the last three rows of stay-bolts at the front and back end, as shown in Fig. 1, have been used in a number of engines recently constructed by the American Locomotive Company for the Chicago & Northwestern Railroad. The stay-bolts are placed in the concave corrugations,

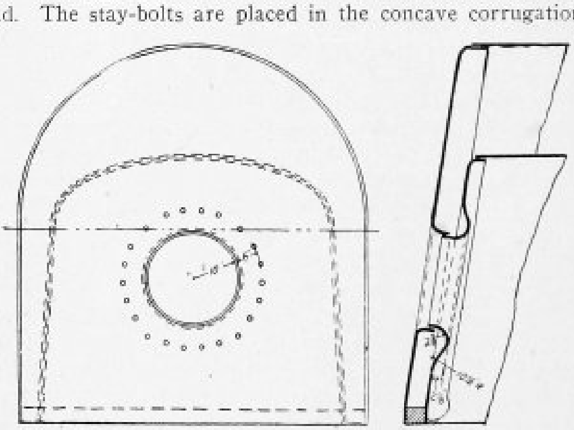


FIG. 3.—THE O'CONNOR DOOR SHEET.

and are thus partly protected from the action of the fire, as the depth of the corrugation is ¾ of an inch. The position of the stay-bolts is clearly shown in detail in Fig. 2. These corrugations not only strengthen the sheet but provide more elasticity for distributing the strains of expansion and contraction, preventing cracks, etc. The heating surface of the side sheets is also increased about 15 percent by the corrugations. In connection with these corrugated side sheets added flexibility is given to the fire-box by the use of the O'Connor door sheet, in which, as shown in Fig. 3, the flange at the door is made of a much larger radius than customary, thus increasing the flexibility of the sheet and distributing the stresses which concentrate at the flange. The increased water space around the door provides better circulation and prevents the accumulation of scale, thus prolonging the life of the sheet. Reports given at the recent convention of master boiler makers showed that this form of door sheet practically does away with cracked door holes, and so reduces the cost of repairs on this part of

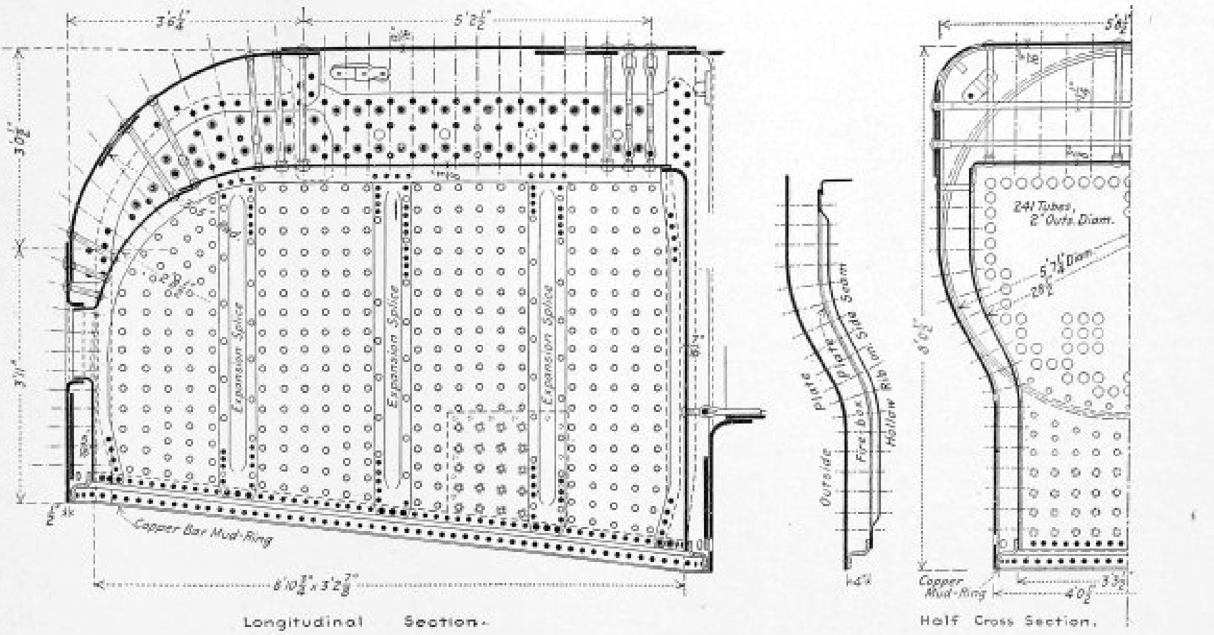


FIG. 4.—DETAILS OF THE LAUGHRIDGE FIRE-BOX.

the fire-box to almost nothing. This form of corrugated fire-box, with O'Connor door sheets has apparently given good satisfaction.

A more recent type of fire-box with expansion side sheets is being manufactured by the Laughridge Fire Box Company, of Dunkirk, N. Y. This fire-box, as shown in the illustration, Fig. 4, is of the Belpaire type. The side sheets are made in four sections with vertical seams, as shown in Fig. 4. The edges of the sections are slightly separated to form open joints, and the seams are closed by vertical strips of U-section on the inside of the fire-box. The flanges of the strips are riveted to the edges of the two adjacent plates, and the hollow rib thus formed allows a variable movement in different parts of the sheet. The U-shaped strips are of the same grade of steel as the plates and are pressed to shape by a former. One of these strips is shown in detail in Fig. 5.

Both longitudinal and vertical movement of the fire-box is provided for by a flexible mud-ring, consisting of a Z-shaped copper bar, ⅝ inch thick. This bar has rounded angles and is riveted to the inner and outer plates through its flanges. If it is desired to use the ordinary rectangular mud-ring, a flexible connection is obtained by stopping the inside sheet about 4½ inches above the mud-ring, and closing the gap with a horizontal copper strip of U-section, having the upper flange riveted to the plate and the lower flange riveted to the mud-ring, as shown in Fig. 6.

The back head of this fire-box is curved so as to provide for longitudinal movement, thus provision is made for a flexible movement in all directions and at all places where an excessive strain is liable to be induced.

This type of fire-box has been quite largely used on the Hocking Valley Railroad and the Ohio Central lines, and the reports seem to indicate that they are very satisfactory. It is estimated that for a period of ten years the cost of maintenance (and renewals of ordinary fire-box) would be $600 for the Laughridge and $3,400 for the ordinary fire-box, showing a saving of $2,800 in favor of the former. This is exclusive of the saving due to the shorter time which the former engine would spend in the shops for repairs.

The following is an abstract of a report made by Mr. S. S. Stiffey, superintendent of motive power of the Hocking Valley Railroad, on the comparative results obtained with two similar passenger engines of the 4-4-0 type, running in the same service; one of which had an ordinary fire-box and the other a Laughridge fire-box. The report is for a period of two years, ending with March, 1906:

"These engines are working in a district with very bad water. While the life of a fire-box is very much shortened and the cost of maintenance very materially increased, because of this fact, the relative difference between the life of the Laughridge and the ordinary fire-box, and the cost of maintenance of same, will remain the same under ordinary or most favorable conditions. As a basis of comparison, we have used passenger locomotives Nos. 76 and 80. Engine No. 76 was built in April, 1900, and equipped with an entirely new fire-box

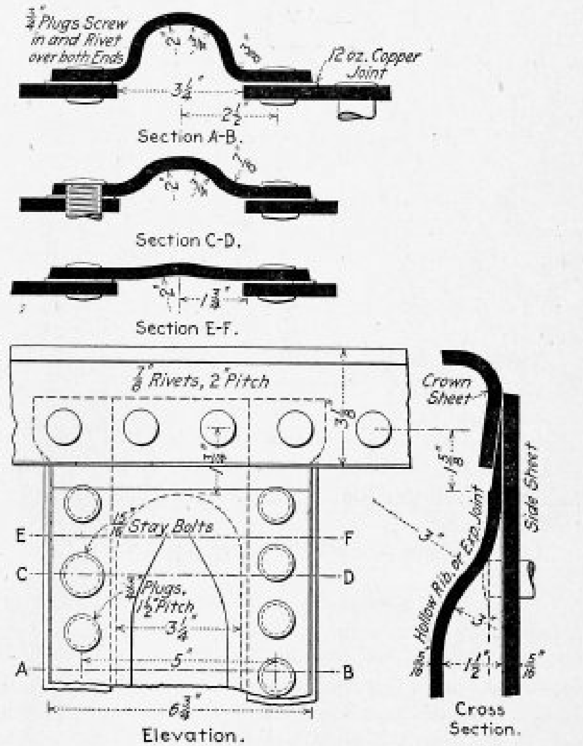


FIG. 5.—EXPANSION SEAM OF THE LAUGHRIDGE FIRE-BOX.

of the ordinary type in March, 1904. Engine No. 80 was built in March, 1904, and equipped with the Laughridge type of fire-box. Each of these engines has cylinders 18 by 26 inches, and the maximum boiler presure is 180 pounds. These engines are of practically the same type, with the exception of the fire-box; the fire-boxes are of the same age, and the engines have worked side by side over the same track and in the same territory.

"In October, 1905, after running nineteen months and 108,333 miles, engine No. 80 (equipped with Laughridge fire-box) had all tubes renewed to obviate the possible collapsing of tubes, due to scale packing and the fact that the boiler was full of mud. Aside from sag, occasioned by scale packing and mud, the tubes were in perfect condition, and have so been maintained without rebeading or any attention due to the push or pull of the backhead. The expansion or welt strips connecting the sectional side sheets in this fire-box have received no attention; they are in good condition, and will not have to be

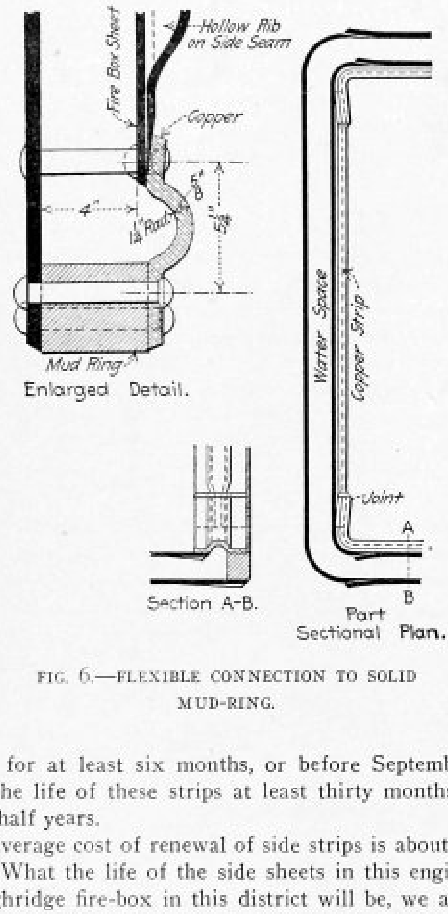


FIG. 6.—FLEXIBLE CONNECTION TO SOLID MUD-RING.

renewed for at least six months, or before September, 1906, making the life of these strips at least thirty months, or two and one-half years.

"The average cost of renewal of side strips is about $135 per engine. What the life of the side sheets in this engine, or of the Laughridge fire-box in this district will be, we are as yet unable to determine from experience, but ten years is not considered an extravagant estimate. The sheets in this particular engine at the present time are practically as good as new, there being no corrugations or cracks. The cost of maintenance of this fire-box and the loss of time of engine from service on account of the same (aside from renewal of tubes, as above) during the period covered by this report was practically nothing.

"As regards the operation of the standard fire-box in engine No. 76, this engine had ninety tubes renewed in March, 1905, and was shopped on Nov. 21 for thorough repairs, including renewal of all tubes and three-quarters of the side sheets. This work, including stripping of engine and in addition to cost of flues, cost approximately $375. During the time this engine was in service, previous to date of thorough repairs, as above (which is the time used for this comparison) it was several times taken out of service and returned to the shop for renewal of a total of sixty stay-bolts, all of which were in the side sheets. This necessitated the stripping of engine to make repairs at a cost of about $165, regardless of and over and above cost or loss of time of engine from service while repairs were being made. This engine will run about twenty months from date of repairs before requiring renewal of the entire fire-box, making the life of an ordinary fire-box in this particular district, with the necessary repairs and attention, about forty months.

"This estimate of the life of an ordinary fire-box with the repairs as above, is extremely generous, as it will be noticed that this is the same length of time that the present fire-box ran when new before requiring these extensive repairs. Allowing the same percentage of breakage of stay-bolts in side sheets for the second twenty months, or after application of three-quarter side sheets, as for the first twenty months (which, as a matter of fact, because of age, must be greater), the cost of repairs and maintenance of this box for the forty months (regardless of loss of time of engine from service on account of repairs and application of three-quarter sheets) would be as follows:

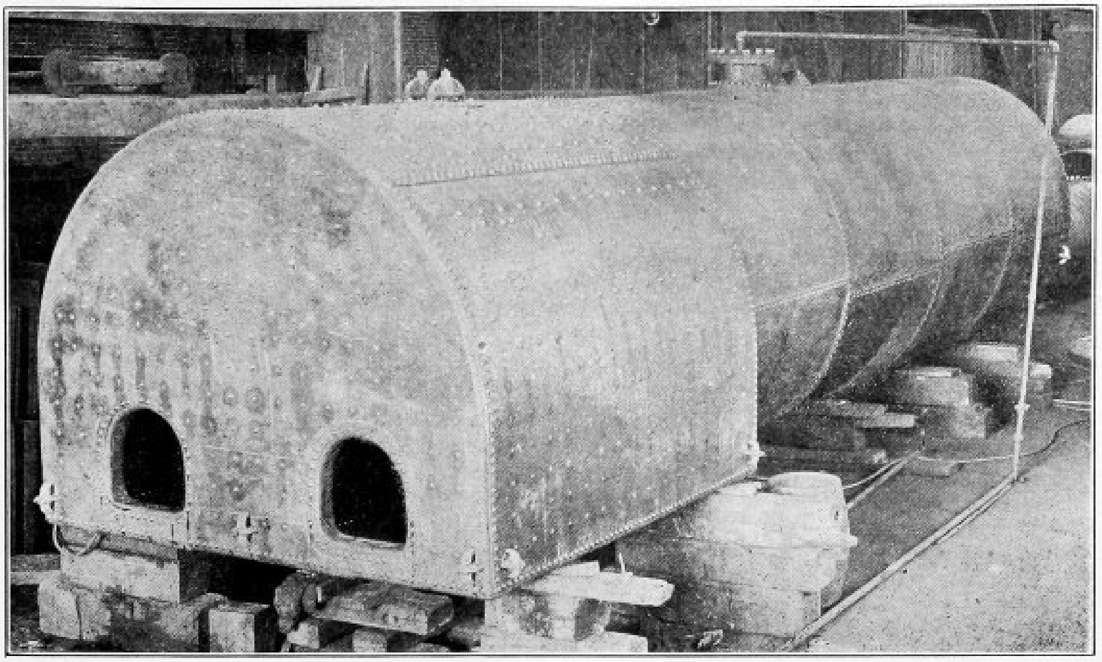
Cost of maintenance first twenty months	$165
Cost of application of three-quarter side sheets at end of first twenty months	375
Cost of maintenance second twenty months	165
Total	$705

"The round-house work on fire-box and tubes of engine No. 80 equipped with Laughridge fire-box during the period covered by this test, as above (two years), was over 60 percent less than on engine No. 76 equipped with standard fire-box for the same period of time. The Hocking Valley, Toledo & Ohio Central and Kanawha & Michigan Railway Companies have over eighty locomotives equipped with the Laughridge fire-box which have been in service from three months to over three years. The engines so equipped which have been in service a sufficient length of time to justify a statement being made with reference to their condition, have shown practically a complete elimination of breakage of stay-bolts.

"There is a very material increase in the life of a set of tubes and a very great increase in the life of the fire-box sheets. As previously referred to in this report, when engine No. 80 had tubes renewed in October, after nineteen months' service and after making 108,333 miles, it had had no repairs whatever to the tubes, and the beads on the tubes were practically as good as new. Even if there were no decrease in the breakage of stay-bolts or increase in the life of a set of tubes, and an overcoming of the disastrous results from cracked side sheets, leaky stay-bolts and flues, the fact that the life of the fire-box is very greatly increased, and the further fact that it will effect a saving of about 15 percent in the use of coal, much more than justifies the application of this fire-box.

"The life of the Laughridge fire-box is maintained to at least three times the life of an ordinary fire-box, simply by renewal of the expansion strips. This work can be done at a small expense in the round-house, without stripping the engine, and with a very short loss of time of engine from service. In the maintenance of an ordinary fire-box to renew or replace stay-bolts or to apply three-quarter side sheets, the expense is very much greater. The length of time that the latter locomotive is kept out of service for these repairs and application of side sheets is also greater."

Reports such as this show the great advantage of flexibility in locomotive fire-boxes, both as regards length of service and decreased cost of repairs. A fire-box that will last more nearly the length of the life of the material of which it is made is greatly to be desired, and flexible connections for the rigid parts seem at present to offer the best solution of the problem.

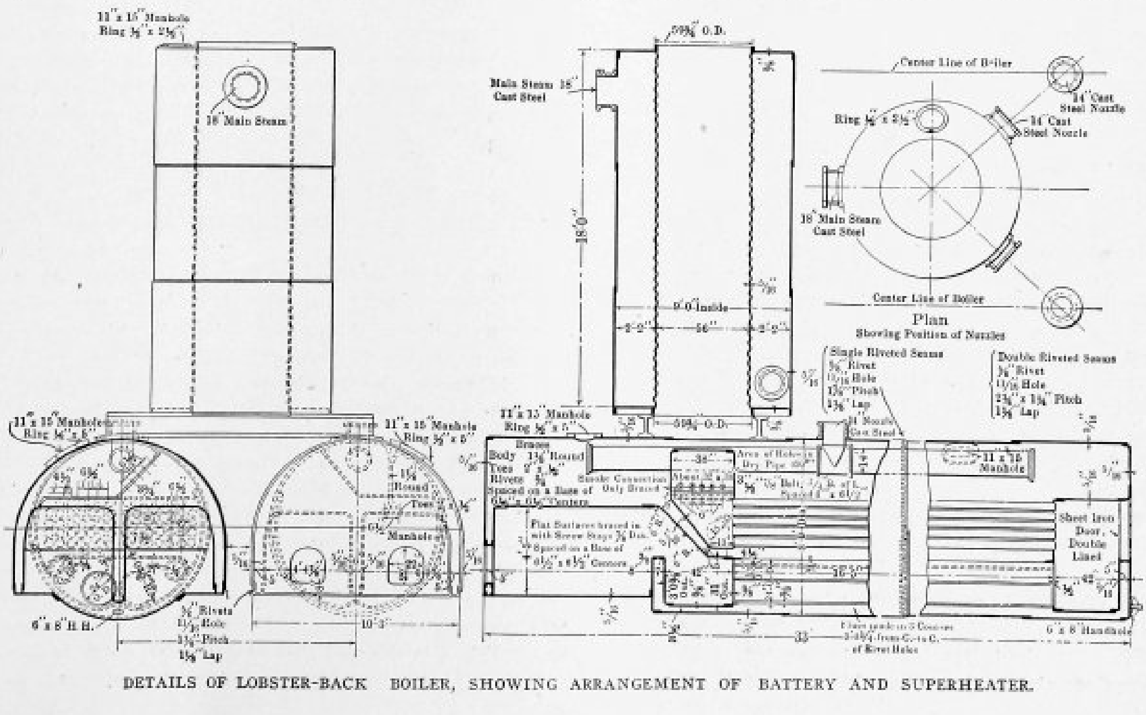


A LOBSTER-BACK BOILER UNDERGOING HYDRAULIC TEST.

The Lobster-Back Boiler.

The lobster-back boiler is a type which is little used to-day except for marine purposes, where only low pressure is needed, as in connection with a slow-speed long-stroke beam engine, such as is used on shallow-draft boats and river steamers. From its external appearance the boiler is apparently a plain tubular boiler with a modified form of locomotive fire-box. Looking at the detailed drawings, however, it will be seen that its construction is much more complicated. The furnaces, of which there are two, are somewhat similar to the furnaces of a locomotive boiler, being surrounded on the sides and back with a water-leg. At the front of the furnaces, however, is a water-leg arch, over which the hot gases pass to a combustion chamber. Four large flues lead from this combustion chamber to a second combustion chamber in the rear of the boiler, from which a large number of ordinary boiler tubes lead back to a third combustion chamber or smoke-box located directly over the first one. The opening from this chamber, or smoke-box, for the exit of the furnace gases is on one side of the boiler above the center line. This unusual arrangement is due to the fact that these boilers are usually installed in batteries of two each, each battery being supplied with a common superheater.

The superheater consists of a vertical cylindrical shell of approximately the same diameter as the boiler, containing an inner concentric corrugated flue, which serves as the lower part of the smokestack. The shell of the superheater and the



DETAILS OF LOBSTER-BACK BOILER, SHOWING ARRANGEMENT OF BATTERY AND SUPERHEATER.

inner flue are made sufficiently strong, so that no bracing is required between the two surfaces. From the plan view of the superheater it will be seen that a steam pipe leads directly from the dry pipe of each boiler to the lower part of the superheater, while one common main steam outlet is located at the top of the superheater. The superheater is supported by heavy I-beams resting across the tops of the boilers.

The particular boiler, of which a photograph and detailed drawings are shown, was built by P. Delaney & Company, Newburgh, N. Y., for the steamer *William F. Romer*, of the Central Hudson Steamboat Company, Newburgh, N. Y. The boiler is 33 feet long by 8 feet 9 inches diameter, and contains two flues, 24 inches diameter; two flues, 13 inches diameter, and sixty-eight tubes, 3 inches diameter by 16 feet 6 inches long. The working steam pressure is 55 pounds per square inch. The superheater is 9 feet in diameter by 18 feet high and contains a corrugated flue 5/16 inch thick and 56 inches in diameter. The grate area is 65 square feet and the heating surface about 2,000 square feet, making a ratio of heating surface to grate area of 30.8 to 1.

The shell of the boiler is made in four courses of 5/16-inch steel plate of 60,000 pounds tensile strength. The circumferential seams are single-riveted with ⅝-inch rivets, spaced 1⅞ inches between centers. The longitudinal seams are all double-riveted lap joints, fastened with ⅝-inch rivets spaced 2¼ inches between centers, the distance between rivet lines being 1¼ inches. The heads of the boiler are 5/16-inch steel plate and are braced to the fire-boxes and combustion chamber with ordinary screw stay-bolts, ⅞ inch diameter spaced 6½ by 6½ inches. The upper portion of the heads, or the segment above the fire-boxes and flues, are braced by 1⅛ inches diameter through braces. The tops or crowns of the fire-boxes, which are flat, are braced with an ordinary form of girder stay.

The steam nozzles and fittings of the boiler are of cast steel. A cylindrical dry pipe, 14 inches in diameter, insures that comparatively dry steam will be carried to the superheater. The area of the holes in the dry pipe is 450 square inches, or nearly three times the area of the main steam outlet. A manhole is located on the top of the shell at either end of the boiler, and ten or twelve handholes are located at convenient points in the water-legs, to aid in cleaning the boiler. Access is gained to the rear of the combustion chamber for cleaning and repairing the tubes through a large opening ordinarily covered with a sheet iron double-lined door.

Another Word on the Brick Arch.

The following quotation was recently published in a certain technical paper:

"It is of interest to note that in the recent convention of the Master Boiler Makers' Association, the remarks of the speakers indicated a general abandonment of the brick arch in locomotive practice, chiefly because of the unreliability of arch tubes as generally applied, together with some vague impression that its use was detrimental to the back fire-box sheets, and possibly the side sheets. To one unacquainted with the process by which devices rise and fall, and railroads in general, those conditions might appear somewhat absurd. But to those familiar with the idosyncrasies developed on railroads, the conclusions are not surprising. The factor of fuel economy is given so little regard in this country that a very little trouble with any device tending to such an end is sufficient to condemn it."

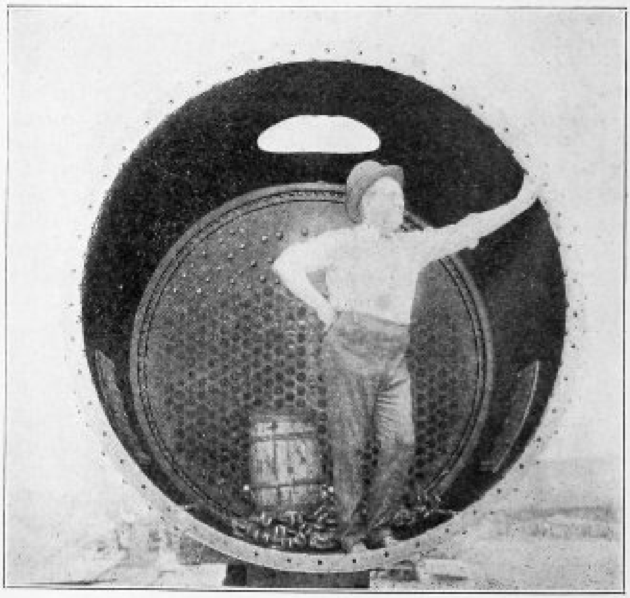
It may be admitted as true that the "factor of fuel economy is given so little regard" on railroads, that they take very little trouble. But the boiler makers, having had daily opportunities for close observation, were able to speak at their convention from their own experience, and that experience, which would be legal evidence in a court of justice, should not be lightly discredited. Without commenting on their reasons, I would suggest thought on two other reasons why the brick arch should be abandoned:

First. Carbon dioxide is one of the products of combustion. It is the resultant of the perfect union (combustion) of carbon and oxygen. It is not combustible. It is 50 percent heavier than air. In its own heat it has energy aided by the draft to rise and pass out of the fire-box to the smokestack, but if it has not sufficient heat to energize it, or if there be not sufficient draft to draw it out of the furnace, or if its exit from the furnace be hindered by a brick arch, it spreads over the fire-box as a diluent, and the temperature of the furnace is reduced by its failure to fully move out with the draft.

Second. The gases which rise from the fire-bed gain nothing by contact with a brick arch. Their tendency is to lose heat in touching a solid.—*John Livingstone, in the Railroad Gazette.*

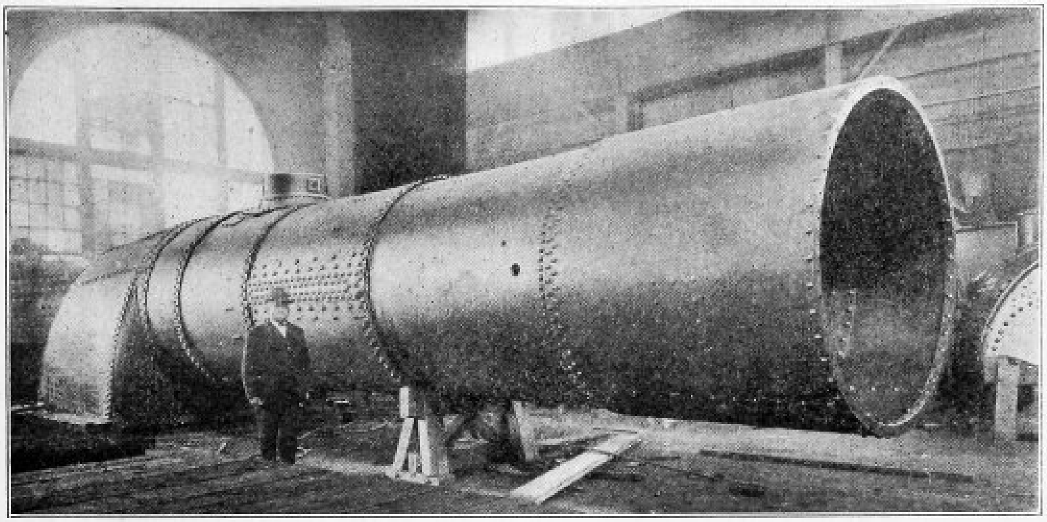
The Largest Locomotive Boiler.

All records for large locomotive construction have been broken by the American Locomotive Company, which has recently completed the first of an order of three Mallet compound locomotives for the Erie Railroad. The Mallet compound locomotive is a type which has only recently been introduced to American railroads. Three years ago a very



THE SMOKE-BOX OF THE BOILER IS 87 INCHES IN DIAMETER.

large locomotive of this type was built by this same company for the Baltimore & Ohio Railroad, and more recently the Baldwin Locomotive Works has completed an order of five of the same general type, but slightly larger in size, for the Great Northern Railroad. These engines have been used in heavy freight service as pushers, in order to assist the regular consolidation freight locomotives over heavy grades. As the size and weight of a train is limited by the capacity of its engine to haul it over the steepest grade in the road, it is evident that if additional power can be obtained on these grades the weight of the trains may be very much increased. The concentration of so much power in single units as is accomplished in the type of locomotive herewith described has been found an economical way of dealing with this problem.



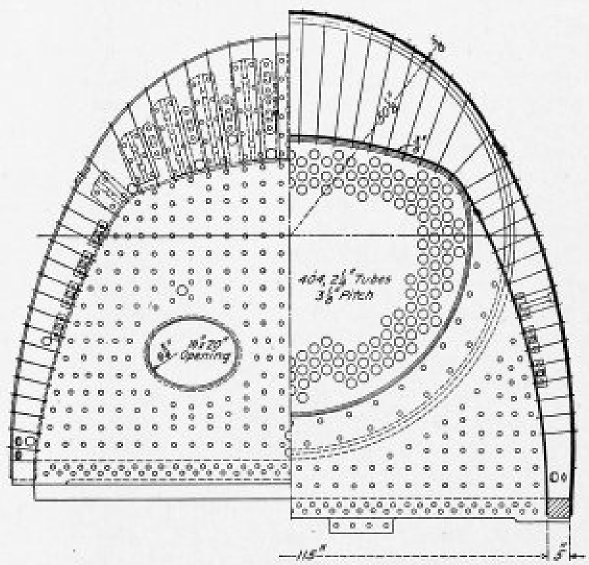
BOILER OF THE NEW MALLET COMPOUND LOCOMOTIVES FOR THE ERIE RAILROAD.

The immense size of the low-pressure cylinders (39 inches diameter) permits them when used as simple engines with live steam to exert a very great tractive effort—120,000 pounds in the case of the Erie engines as against 94,800 pounds when working compound.

Although the new locomotives for the Erie Railroad are much heavier and more powerful than those which were built for the Baltimore & Ohio Railroad, yet the essential features of the two designs, such as receiver and exhaust pipes, articulated connection between frames, boiler, bearings, power reversing gear, etc., are practically the same. None of these features, most of which are comparatively new and were considered freakish when first put into operation, has failed to give good satisfaction during the few years in which they have been used.

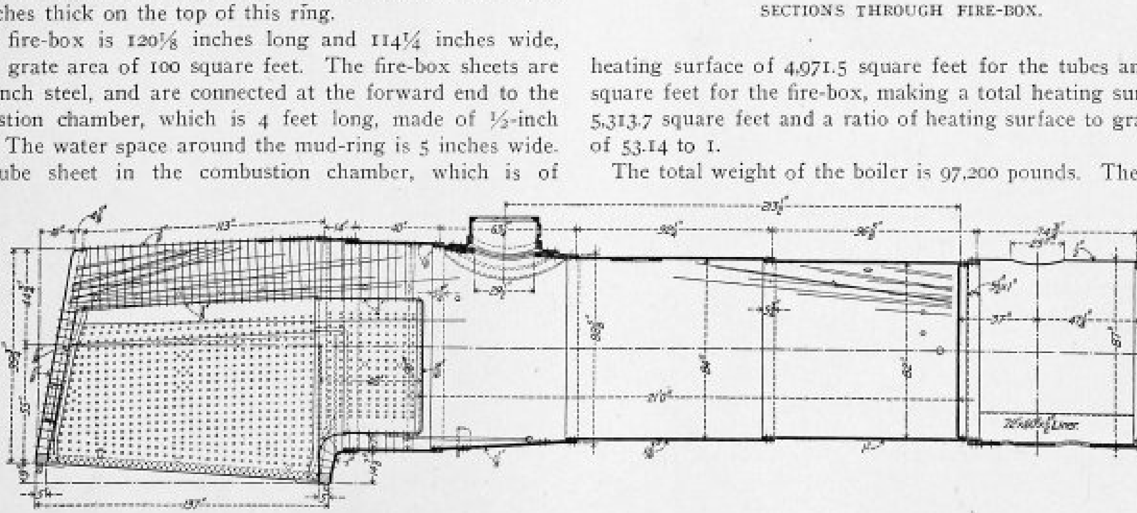
The boiler of this huge locomotive is of the straight conical type, with a diameter of 84 inches and a working pressure of 215 pounds. It has a wide fire-box of the Wooten type, and is radially stayed. The shell consists of two straight rings, the inside diameter of the first, the smallest course, being 82 inches, connected by a conical ring to the largest course, which is 96 inches in diameter. The heaviest ring of the shell is 1 3/16 inches thick. This is reduced at the smallest diameter to 1 inch. A cast steel steam dome is placed on the tapered ring, and with its base and stiffening ring forms a mass of metal 3⅜ inches thick on the top of this ring.

The fire-box is 120⅛ inches long and 114¼ inches wide, with a grate area of 100 square feet. The fire-box sheets are of ⅜-inch steel, and are connected at the forward end to the combustion chamber, which is 4 feet long, made of ½-inch plate. The water space around the mud-ring is 5 inches wide. The tube sheet in the combustion chamber, which is of 9/16-inch plate, is connected to the front tube sheet by 404 2½-inch tubes, spaced 3⅛ inches between centers. These tubes are 21 feet long and have a gage of .125 inch. This gives a heating surface of 4,971.5 square feet for the tubes and 342.2 square feet for the fire-box, making a total heating surface of 5,313.7 square feet and a ratio of heating surface to grate area of 53.14 to 1.



SECTIONS THROUGH FIRE-BOX.

The total weight of the boiler is 97,200 pounds. The weight



LONGITUDINAL SECTION OF ERIE MALLET COMPOUND BOILER.

of the water in the boiler is 42,700, making the total weight of the boiler when filled with water 139,900 pounds. The total weight of the locomotive is 410,000 pounds, and it has a tractive effort of 94,800 pounds. The tractive effort of 94,800 pounds will be developed when the engine is working compound, but when live steam is admitted in the low-pressure cylinders the tractive effort is increased to about 120,000 pounds. Under these conditions the locomotive can haul on the level, at a speed of 8 or 10 miles an hour, about 250 loaded freight cars, or a train 2 miles long.

The amount of heating surface in this boiler has not been increased proportionally to the increase of its other dimensions over those of previous locomotives, due to the fact that such a large combustion chamber has been used. The efficiency of the combustion chamber has been so thoroughly demonstrated, however, that the loss of the heating surface in the tubes does not mean a loss in the efficiency of the boiler.

Tests of Very Mild Steel Tube Sheets

According to the *Organ der Fortschritte des Eisenbahnwesens* the repair shops of the Prussian railroads for the line running from Cologne to Nippes have recently made a test of some steel tube sheets under the following conditions:

The feed-water that is used in engines which are repaired at these shops is very bad, with the result that after a short term of service, cracks are apt to appear in the red copper tube sheets, so that they are soon unfit for service. The cracks begin on the fire side and gradually increase in depth until they extend through the sheet. The cracks always run on a line with the second vertical row of tubes, and on each side of the sheet, and work across the first five bridges between the tubes. They then extend over them all until the sheet is rendered useless. It has been noted for several years that the method of building the boiler had little or no influence upon the production of these bridge cracks. It can, however, be said that the flexible or expanding stay-bolts and the use of short wood fire-boxes has slightly improved the situation. The principal elements influencing the matter on the other hand are: The

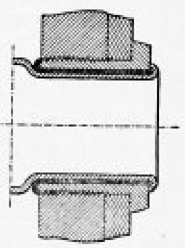


FIG. 1.—THE TUBES ARE EXPANDED INTO COPPER FERRULES.

steam pressure and the nature of the scale. As the pressure is increased, and with it the temperature of the copper, the plate is weakened in its tensile strength accordingly. In the matter of scale, its influence depends upon its permeability. The waters in the neighborhood of Cologne are charged with magnesium salts, and the locomotives carrying a pressure of 170 pounds to the square inch begin to show cracks in ten or twelve months, and those carrying 200 pounds pressure in from four to six months, while others working in a territory where the water is better will run from two to three years without developing any cracks in their tube sheets. The reduction in the number of tubes in the upper corners of the sheets for the purpose of increasing the size of the bridge does not seem to have any influence. The means taken to increase the life of the sheet is by the insertion of a screwed bushing, as shown in the engraving. The number of each is limited to 40, and when more than this is required the sheet is changed. As will be seen from the engraving, this method of repairing consists in applying a copper washer about ⅜ inch thick to the fire side of the sheet, and holding it in place by a screwed bushing of very mild steel, into the inside of which the tube is expanded, and as every kind of hammering is positively forbidden it will be seen that the adjustments will have to be made very carefully in order to secure tightness. This is the

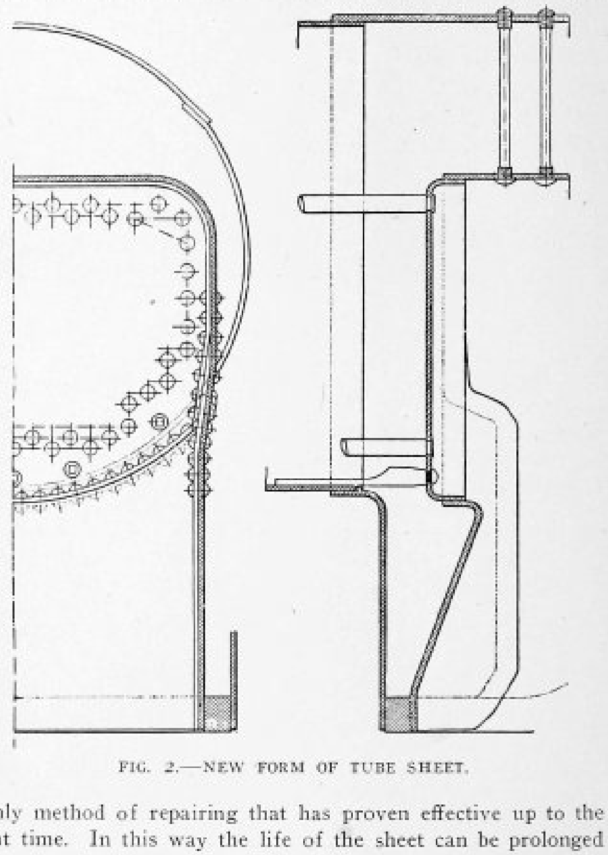


FIG. 2.—NEW FORM OF TUBE SHEET.

only method of repairing that has proven effective up to the ent time. In this way the life of the sheet can be prolonged from two to three years. When it is necessary to change the sheet it takes from four to six weeks work at the Nippes shop.

This rapid destruction of the tube sheets has naturally led to investigations in order to obtain a metal offering greater resistance than copper. In these attempts, copper, zinc, iron, silicon bronze and aluminum bronze made by Eckman & Duisbourg have been tried, but all these attempts have resulted in failure.

On the other hand, trials that were made in 1894 and 1896 with fire-boxes made of very mild steel, showed that the steel in direct contact with the incandescent coal changed so rapidly that after only three or four months it was necessary to replace the fire-box, although the whole zone that was not in direct contact with the coal was still in very good condition. A chemical study of the steel that had thus been changed showed that it was due to a rapid carbonization of the metal in direct contact with the coal. Thus in a sheet 5/16 inch thick the percentage of contained carbon rose to .13 percent instead of .01, which it originally had. True cementation, therefore, had taken place, as confirmed by the tensile and bending test. The conclusion of this inquiry was, then, that it was necessary to continue to make those parts of copper that were in direct contact with the coal, while those that were in contact with the gases could be made of steel. On account of the unusual form which it would thus be necessary to give to the fire-box, it was decided not to resort to this last expedient until every other method had been exhausted. Not until 1900 was an eight-coupled engine fitted with a new tube sheet that was to be subjected to a pressure of 170 pounds. The fire-box had never run more than two years. This sheet was run for more than three years in spite of the bad quality of the feed-water, and without showing the slightest signs of deterioration. At the end of the three years the sheet was subjected to an exceedingly careful inspection, and it was found to be free from defects. Furthermore, during these three years far less trouble had been experienced with the tubes than with the ordinary copper sheet. The maximum elongation of the tube holes amounted to .06 inch. As a result of this trial, the same system of construction was applied to a six-coupled engine, carrying 200 pounds pressure. The new copper sheet, which had been put in this engine in June, 1901, had developed cracks in the month of November of the same year. It was repaired by means of the screwed bushings, but the sheet had to be replaced in January, 1904. The locomotive left the shops in May, 1904, with a composite copper and iron sheet, and was put into service on the line between Cologne and Treves in heavy traffic. This sheet has in the meantime, that is, during the period of about two years, remained in perfect condition, and has thus shown that this system of construction meets all the requirements of the heaviest service.

The engraving given herewith shows the design of the new sheet. It presents no difficulties in the boiler shop, simply requiring that care be employed in putting it together, and that attention be turned to the point where it is attached to the steel tube sheet; to the side sheets of the fire-box, and to the copper portion of the tube sheet, which is doubled, and thus brings four thicknesses together. Naturally, with this system, a construction as applied to a new boiler is so arranged as to do away with the sharp angles.

It is also to be noted that the tubes are expanded into copper ferrules of .06 inch thickness, set in the sheet as is common practice with steel tube sheets. The copper portion of the tube sheet is held by copper stay-bolts, and not of iron, for experience has shown that the heads of iron stay-bolts will sink down into the copper and eventually pull out, thus giving an opportunity for failure.—*Railroad Gazette*.

Layout of a Taper Connection, the Lower Base of Which is Rectangular and the Upper Circular.

BY HENRY MELLON.

The connection shown in Fig. 1 is usually developed by triangulation. The following construction will, however, give practically the same result, and may possibly be found to take less time.

Draw the perpendicular line *CD*, Fig. 2, and at *C* draw *AB* at right angles to *CD*. Lay off *CE* equal to the slant height of the connection, as shown at *CE*, Fig. 1. Then draw the line *FG* parallel to *AB*, making *AB* equal in length to the longer side of the base, and *FG* equal in length to one-quarter of the circumference of the top. Draw the lines *AF* and *BG*. Lay off *CK* equal to one-half the shorter side of the base and erect the perpendicular line *GL*. With *F* and *G* as centers

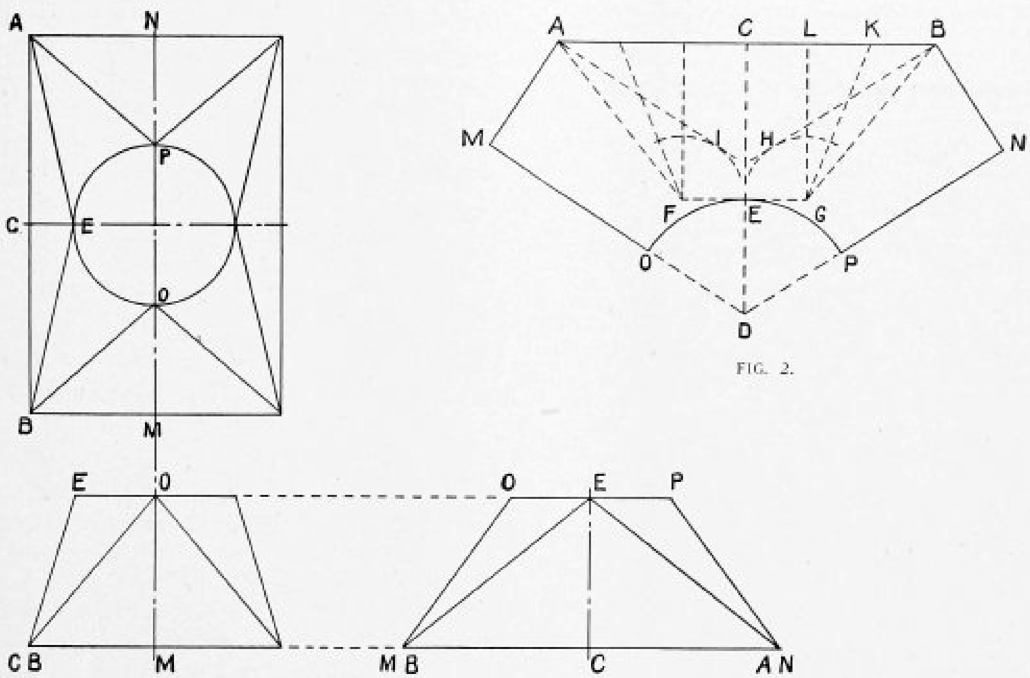


FIG. 1.

FIG. 2.

and a radius equal to *LK*, draw the arcs *I* and *H*. Through *A* and *B* draw lines *AI* and *BH* tangent respectively to these arcs. At *A* and *B* square up the lines *AM* and *BN* perpendicular to *AI* and *BH*. Make the distances *AM* and *BN* equal to *CK*, or one-half the shorter side of the connection. At *M* and *N* draw the lines *MD* and *ND* perpendicular, respectively, to *AM* and *BN*. With *D* as a center, draw the arc *OEP* through the point *E*. Then the figure *MABNPEO* represents the half pattern of the taper connection.

Some Steam Boiler Information.

A cubic inch of water evaporated under ordinary atmospheric pressure is converted into 1 cubic foot of steam (approximately).

Twenty-seven and two-tenths cubic feet of steam, at atmospheric pressure, weigh 1 pound; 13.8 cubic feet of air weigh 1 pound.

One square foot of grate area will consume, on an average, 12 pounds of coal per hour.

In calculating horsepower of tubular or flue boilers, consider 15 square feet of heating surface equivalent to one nominal horsepower.

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - New York

Christopher St., Finsbury Square, London, E. C.

H. L. ALDRICH, President and Treasurer

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Boston, Mass., 170 Summer St., S. I. CARPENTER.
Chicago, Ill., 625 Monadnock Building, H. S. Moss.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico........	$1.00	.10
Other countries in Postal Union..........	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

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.

Atlanta!

The interest of boiler manufacturers will be centered this month on Atlanta, Ga., where on Oct. 8 the nineteenth annual convention of the Boiler Manufacturers' Association of the United States and Canada will be opened. Little can be added at this time to the announcement which we gave last month regarding the plans for this convention. The plans have been well made and the meetings this year promise to be of unusual interest. Engineers, manufacturers and power users in general look to the boiler makers for a means of increasing the economy and safety of their plants, but little progress can be expected unless the boiler manufacturers make free use of such opportunities as are offered by the work of the association for gaining new ideas and solving difficulties which are impeding their progress.

Testing Stay-Bolts.

The requirements of the New York laws for the inspection of locomotive boilers, regarding stay-bolt testing, may not differ very much from the usual requirements of most railroad companies, but at the same time they admit of no carelessness. More boiler explosions can be traced to broken stay-bolts than to almost any other cause. The only way to successfully prevent these failures is by careful and thorough inspection. It is better to have a few good bolts removed by mistake than to leave a number of broken ones in service. The failure of one bolt places an excessive strain on the neighboring stays, with the result that the trouble soon spreads. The best method of testing the bolts may be a subject for discussion, but an experienced inspector will usually have little difficulty in detecting a failure either when the boiler is under hydraulic pressure or when the fire sheet is free to vibrate. The bolts should always be tapped on the fire side, and if there is no pressure on the boiler the water should all be drained off, as otherwise a breakage might pass unnoticed. Tell-tale holes may give warning of a broken bolt when in service, but it is too easy for these to become plugged to depend upon them absolutely.

The Lusitania.

Some months ago we published a complete description of the boilers, up-takes and stacks of the *Mauretania*, a sister ship of the giant *Lusitania*, which has recently completed her maiden voyage to this country. Aside from the fact that shipbuilding and boiler making are such closely allied trades, these ships are of particular interest to boiler makers, because in them are installed the largest marine boiler plants ever placed in any ships. Twenty-five boilers, twenty-three of which are eight-furnace double-ended and two four-furnace single-ended boilers, with a steam pressure of 195 pounds are required to furnish steam for turbine engines of an aggregate horsepower of 68,000, in order to drive the monster steamships at their designed speed of 25 knots per hour.

The *Lusitania* is 785 feet long, 88 feet wide, 60 feet 6 inches deep, with a gross tonnage of 32,500 tons. At a draft of 33 feet she displaces 38,000 tons, while at a draft of 37½ feet her displacement is 45,000 tons. When launched at the Clydebank shipyard of John Brown & Company, Ltd., the *Lusitania* weighed about 16,000 tons. Propulsion is obtained by means of four propellers, connected to Parsons turbines of a total horsepower of 68,000. Accommodation is provided for 552 first-class, 460 second-class, and 1,200 third-class passengers.

The boilers are divided into four groups in four different stoke holes. The products of combustion are carried off through four elliptical funnels, 130 feet tall above the grates and with a major inside diameter of 24 feet. The double-ended boilers are each 17 feet 6 inches in diameter by 22 feet long, and have 344 stay-tubes and 720 plain tubes, making a total of 1,064. The total heating surface of one boiler is 6,593 square feet, and the grate area 169 square feet. The total heating surface of all the boilers is 158,350 square feet, the total grate area 4,048, which gives a ratio of heating surface to grate area of 39.1 to 1. There are 192 Morrison corrugated furnaces, 45 inches inside diameter and with a maximum diameter of 49½ inches and a thickness of 21/32 inch, each of which has a separate combustion chamber. The boiler shells are of high tensile steel, with a maximum strength of 79,000 pounds, while the heads are, as usual, of mild steel.

It is interesting to note that the aggregate area of the grates in the ship is larger than two city lots, each 20 by 100 feet, and that the heating surface, 3.64 acres, is very nearly the area of a New York City block, 200 by 800 feet. The total length of each of the 25,536 tubes is 8 feet ⅜ inch, and if all the tubes were placed end to end they would extend for a distance of 205,086 feet, or 38.85 statute miles, 261 times the overall length of the ship.

TECHNICAL PUBLICATION.

Official Proceedings of the First Annual Convention of the International Master Boiler Makers' Association. Pages, 92. Illustrated. Edited by Harry D. Vought, secretary of the association. Paper covered. New York, 1907.

This book contains a complete report of the proceedings of the first annual convention of the International Master Boiler Makers' Association, which was held at the Hollenden Hotel, Cleveland, Ohio, May 21, 22 and 23, 1907. The scope of this organization, which is the outcome of the union of the Master Steam Boiler Makers' Association and the International Railway Master Boiler Makers' Association, is too well known to need comment. The subjects brought up and discussed at the convention, upon which papers were prepared, included "Arch Tubes," "Brick Arches," "Hydrostatic Tests of Boilers," "Belpaire vs. Radial Stayed Boilers," "Leaky Stay-Bolts," "Flexible Stay-Bolts," "Fire Doors," "Flue Welding and Setting" and "Steel vs. Iron Flues." In addition to these papers and the discussion upon them, the book contains a copy of the constitution and by-laws adopted by the association, a list of the members and other important information regarding the work of the association.

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 is the origin of the term "O.G."? INQUISITIVE.

A.—"O. G.," or as it is more frequently written, "ogee," is the term applied by mechanics and architects to a double reversed curve formed by the union of a concave and convex line. Some claim that the word "ogee" is derived from "ogive," which is an architectural term meaning "a pointed arch." The derivation is, however, uncertain. The letters "O. G." are used in the same way that S. L. and T. are used to denote certain mechanical or architectural forms which resemble them in shape.

Q.—Does live steam flow faster through a large or a small pipe, both pipes being subject to the same boiler pressure?

B. M. J.

A.—The velocity of steam through a pipe depends upon the difference in pressure at the two ends of the pipe and the friction of the steam on the surface of the pipe. Therefore, since the two pipes are subject to the same pressure, there would be no difference in the velocity of the steam if it were not for the friction of the particles on the surface of the pipe. This varies as the square root of the diameter, therefore the velocity would be greater in the larger pipe.

Q.—What is the rule for finding the strength of a butt-strap seam and also a lap seam with one and two rows of rivets?

MANILA.

A.—In finding the strength of any riveted joint it is customary to find the percentage strength of the joint for one pitch of rivets as compared with a similar section of the solid plate. Then the total strength of the joint may be found by multiplying the strength of a section of the solid plate of the same length as the joint by this percentage.

To find the percentage strength of a joint, it is necessary to consider all the possible ways in which the joint can fail, and see which part of the joint, whether the rivets or plate between the rivets, will be the weaker for resisting the forces tending to tear the joint apart. In a well-designed single-riveted lap-joint there are two general ways in which it may fail. The section of the plate between the rivet holes may break, or the rivets may be sheared off. Thus it is necessary to find the percentage strength of the section of plate between the rivet holes as compared with the solid plate, and also the percentage strength of the shearing resistance of the rivets as compared with the strength of the solid plate. The smaller of these two percentages will be the percentage strength of the joint. If there is a double row of rivets, the resistance of the rivets to shearing will, of course, be greater. Also the section of plate between the rivet holes will be greater than in a single-riveted joint, as the pitch can be made somewhat larger.

A single-riveted butt joint is practically never used; for, although the percentage strength of the rivets is increased, due to the fact that the rivets are in double shear, yet the pitch can be made no longer than in a single-riveted lap-joint, and, therefore, the net section of the plate between the rivet holes will not be any stronger. A double-riveted butt-joint would be figured the same as a double-riveted lap-joint, except that the rivets, if inside and outside cover straps are used, will be in double shear.

PERSONAL.

Mr. Robert Wilson, who was formerly employed in the Elizabethport shops of the New Jersey Central Railroad, has recently accepted a new position in Plainfield, N. J.

Mr. E. S. Fitzsimmons, formerly general foreman boiler maker of the Erie Railroad, with headquarters at Meadville, Pa., has been appointed to the position of master mechanic of the Cincinnati division of the Erie, at Galion, Ohio. Mr.

E. S. FITZSIMMONS.

Fitzsimmons was born in Columbus, Ohio, and, while he was very young, went West to start his railroad career with the Rock Island Railroad. He stayed with the Rock Island ten years, and from there went in succession to the Lackawanna, the New York, New Haven & Hartford and the Erie. During the past two years and a half he has been general foreman of the boiler makers of the Erie between New York and Chicago, with headquarters at Meadville, Pa. Mr. Fitzsimmons is a young man, full of energy, and with a splendid reputation for railroad work. He has been an enthusiastic member of the Master Boiler Makers' Association, and, at the annual convention last May, was elected first vice-president of the new International Master Boiler Makers' Association.

COMMUNICATIONS.

Second Hand Boilers.

Editor The Boiler Maker:

I often hear men tell about the good bargains which they have made in second-hand boilers. They frequently boast about having obtained a certain boiler at a greatly reduced price, but after a few months use, when something unlooked for happens to the boiler, we do not hear so much about it. After looking into the second-hand boiler question, the writer has come to the conclusion that while there are some first-class second-hand boilers available under certain conditions at reasonable prices, there are numerous discarded boilers which are totally unfit for anything but scrap.

Boilers, above all other second-hand articles, should receive careful consideration and examination before the bargain is

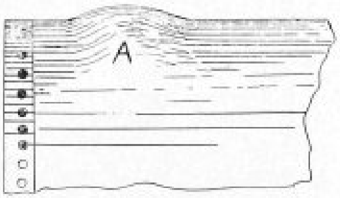


FIG. I.—A HUMP DEVELOPED.

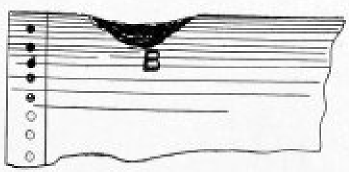


FIG. 2.—THE HUMP WAS CUT OUT.

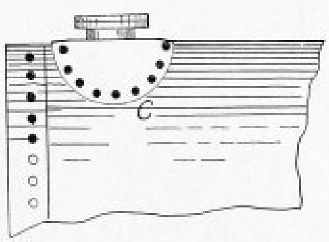


FIG. 3.—AND A FLANGED FITTING RIVETED IN ITS PLACE.

closed. It is an easy matter for the vendors of second-hand materials to cover defects. When you are buying second-hand material you must take your chances. The manufacturer or dealer in new boilers is very careful to properly inspect and test his goods before they go out, but the second-hand boiler dealer need not take all this trouble unless he chooses. He advertises second-hand property and sells the boiler to you as a second-hand article at a second-hand price. Therefore, you cannot very well get back at him if the boiler proves to be worthless.

There are, however, many very good boilers available even in the junk shop. When a manufacturing plant outgrows its present capacity new boilers of larger capacity are needed, and the old ones, although they may be in good condition, must go. Hence, the buyer who procures these boilers will not get a bad bargain. There are boilers which are discarded because it is desired to introduce some new system of generating the steam. Such boilers may be good enough for use in smaller establishments. However, the kind of boiler that creates trouble in all steam plants is the junk-pile boiler. There may be corroded plates. There may be weak points in the laps. Leakages may have developed. The tubes may be burned out. The shell may be weakened and nearly ready to collapse. I have known cases in which merely a change in the position of the boiler, even though the same steam pressure be used, has wrought havoc with the plates.

A friend purchased what seemed to be a good second-hand boiler not long since, and had it properly installed at his saw-mill. The price on the boiler was less than half the price of the same outfit when new, and my friend felt that he secured a bargain. But bargain-counter boilers are not to be relied upon. Although nothing had happened to the boiler in the old place, it had no sooner been put into service in its new position than a hump developed on top of the boiler, as shown at (*A*) Fig. 1. It would not do to let this hump remain, so the ingenious man put a machinist to work chipping out the elevated portion, leaving a good-sized manhole opening in the boiler plate, as shown at (*B*) Fig. 2. Then when it came to riveting a plate over this aperture, it happened that there was a part of a flanged heater head available, and as this fitted snugly on the cavity it was duly drilled with rivet holes and riveted on good and tight. Hence, the defect in the boiler was removed and something put in its place which had the appearance of being a necessary fitting. The owner put the boiler on

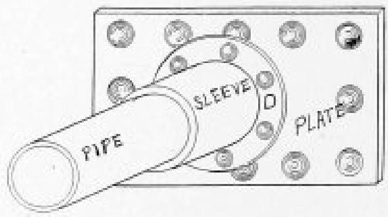


FIG. 4.—COVERING A DEFECTIVE ARRANGEMENT OF PIPING.

the market again and got it off his hands at half what it cost him, then he proceeded to buy a new boiler.

In another case a plate in a second-hand boiler was drilled and the flanged ring (*D*), Fig. 4, was fastened on with rivets. Then a smaller pipe was fitted into the sleeve as shown. This was done to replace a defective arrangement of piping which had been affected by corrosion in a new installation. When the combination was put into use the brazed inner pipe became free. It gradually slipped out from the sleeve, due to the steam pressure, and finally blew out, filling the room with steam and burning some of the men.

If a second-hand boiler is overhauled by reliable parties and guaranteed, it is a different proposition, but the man who seeks second-hand material wants it cheap. Therefore, he usually gets a boiler which may look well on the outside but which, owing to the low price at which it must go, is not safe. An interior examination would reveal the weak points to the buyer, but he is usually devoting his attention and energy to the price, regardless of the condition of the boiler. He finds out his mistake only after he gets the boiler in place. While I believe in the reconstructed or overhauled second-hand boiler which has been put into order by competent firms, I would hesitate to invest in second-hand boilers from unreliable parties or from the junk shops. George Rice.

Boiler Explosions.

Editor The Boiler Maker:

Having read the article in the September issue of The Boiler Maker, entitled "Fallacy About Boiler Explosions," page 276, also having previously read similar articles under the same title in other mechanical journals, the inference drawn is that in case an engineer finds that the water becomes dangerously low in a boiler, exposing the crown sheet to the intense heat of the fire, the proper thing to do is to put on the injectors and put a sufficient amount of water in the boiler, at least there would not be any danger of an explosion in doing so.

If it was the intention of the writer to convey such an idea, I must take issue with him, as I consider it a most injurious, if not dangerous, practice. The sudden cooling and contracting of the metal is liable to crack it, or at least crystallize it, thereby making it unfit for use; and it is possible that the sudden contracting of the material will cause an undue and excessive strain on the seams, thereby weakening them, so that the pressure within the boiler will cause them to give way.

Would it not seem a better practice when an engineer finds himself in such a predicament to deaden the fire as quickly as possible, even though he is compelled to resort to the squirt hose? Then permit the sheet to cool gradually to the normal temperature when it will be safe to inject a sufficient amount of water into the boiler to cover the crown sheet, and if he finds that the heat was not sufficient to spring the seams or rivets and cause them to leak, he will be reasonably safe in bringing the engine to the nearest terminal, after which a careful inspection should be made by a competent mechanic. I do not mean to say that forcing water on a hot crown sheet will always produce an explosion, but it is liable to do so.

The demonstration made by the Pennsylvania people is often repeated on all railroads with the same results. We sometimes find, after an engine has made a trip over the road, that

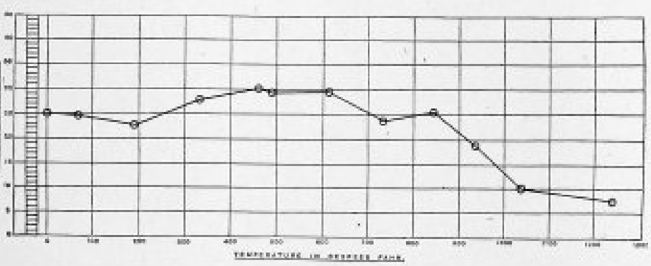


DIAGRAM SHOWING CHANGE IN TENSILE STRENGTH OF STEEL WITH THE TEMPERATURE.

the crown sheet is leaking badly. When a careful inspection is made it is found that the water has been permitted to get too low in the boiler, thereby scorching the crown sheet. We find the sheet was not sufficiently weakened by the intense heat of the fire to bring its resisting force below the pressure within the boiler, therefore it withstood the shock.

Tests made by the United States Government demonstrated the fact that steel boiler plate increases in tensile strength from zero up to 610 degrees F. 1,000 pounds per square inch, from 610 degrees F. and upward it decreases. The greater the degree of heat applied the more rapid is the loss of tensile strength. A sheet that originally stood 80,000 pounds tensile strength per square inch when heated to a temperature of 1,600 degrees F. (a cherry red), was reduced below 1 000 pounds tensile strength. If we know the tensile strength of the material at a given temperature we can determine the force necessary to cause a collapse. If the strength of a crown sheet is reduced by overheating, so as to bring it below the stress caused by the steam pressure in the boiler, the weaker of the two forces is bound to succumb, and the result is a collapsed crown sheet and a violent boiler explosion.

Why a violent explosion? We know that water boils and emits steam at 212 degrees F. at sea level when the pressure of the atmosphere is 14.7 pounds per square inch. We also know that water will boil at a greater elevation at a lower temperature. Why? Because the pressure is less. In order to generate 190 pounds of steam in a boiler it is necessary to apply about 1,197 heat units per pound of water, making the temperature about 377 degrees F. Now, if water will turn into steam at 212 degrees F., atmospheric pressure, with what degree of violence will it turn into steam if turned loose into the atmosphere at a temperature of 377 degrees F? Such is the case when a cown sheet collapses from a weakness developed by low water. It is not the steam alone which is above the water in the boiler that does so much damage; it is the great expansive force of the water changing into steam when the pressure is removed.

There is nothing supernatural or mysterious about boiler explosions. An explosion is the natural result of applying a greater force than the material of the boiler is capable of resisting. The laws of nature are exacting, and when violated the result is disastrous. Eternal vigilance is the price of safety.

T. H. MOONEY.

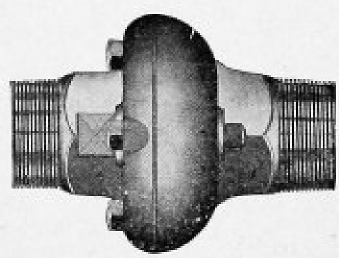
ENGINEERING SPECIALTIES.

A New and Unique Blow-Off Valve.

Considerable attention has been drawn to a recent output of the Patterson-Allen Engineering Company, of Philadelphia, Pa., in the shape of a blow-off valve.

The valve is composed of two saucer-shaped bonnets, set together upon a high pressured gasket with tap-bolts. Upon the lower bonnet is wrought a valve face. The valve slides upon this face, and is actuated by a substantial crank-arm, which, in turn, is actuated by a square-headed post. The square within the case actuates the crank-arm and extends through the bottom bonnet, being seated upon a tapered ground joint, thus doing away with the necessity for a stuffing box, or packing of any kind whatever. The post is dressed square and is operated by a box-lever placed thereon.

The seat in the lower bonnet is raised above the plane of the joint, the valve sliding laterally upon it, wiping it clean at each operation and eliminating the chance of any part of the deposit from the discharge being interposed between the steam-tight surfaces when the valve is closed. The valve at all times is tightly pressed against the seat by the boiler pressure.



THE EVERLASTING BLOW-OFF VALVE.

This feature lends a very desirable quality to the repairing of the valve, as it may be re-surfaced simply by the use of a file.

When the valve is open, the discharge opening is round, of the same diameter as the discharge pipe, the discharge and inlet nipples being arranged so close together that the discharge pipe might be considered continuous and uninterrupted. It will be further noted that the innermost facing of the inlet orifice is slightly choked, insuring the delivery of sediment-laden discharge into the outlet orifice with a minimum impingement upon any of the steamtight members of the valve.

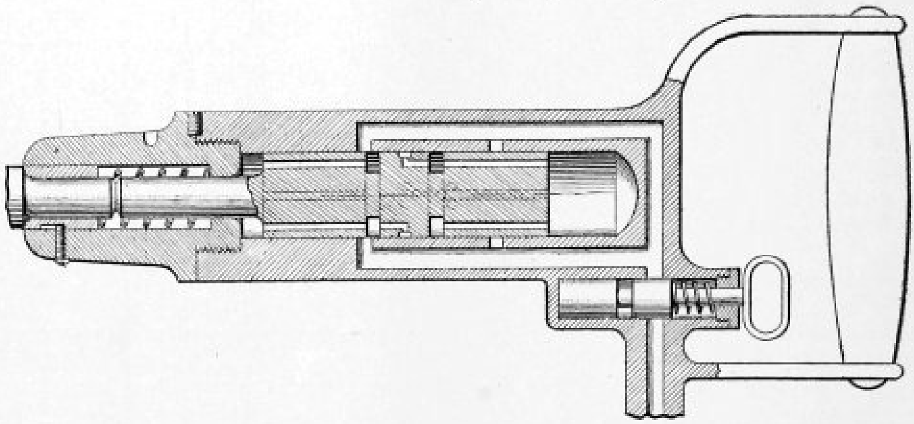
The operation of the "Everlasting" valve is such as to displace any sediment collecting therein, instead of jambing it in its closed position. It is lever-operated and so balanced as to make its operation very easy, the maunfacturers claiming that an effort of only 25 pounds upon an 8-inch lever is required to open and close it against 200 pounds boiler pressure.

The Scully Steel & Iron Company, of Chicago, Ill., have recently been appointed general distributing agents of this valve for the United States.

A New Air Hammer.

A new air hammer has recently been patented by Mr. Joseph Frederick, of Stroudsburg, Pa., and is, we understand, soon to be placed on the market.

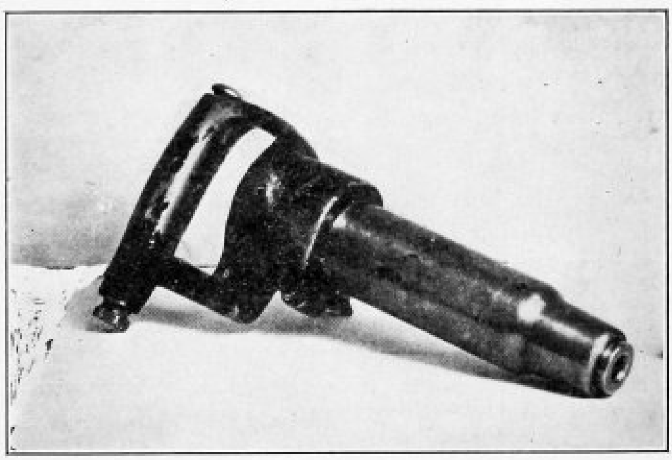
While Mr. Frederick was employed as tool room foreman at the New York, Susquehanna & Western shops at Stroudsburg, he had much trouble with the various air chipping and riveting hammers in use on account of the delicate and com-



SECTIONAL VIEW OF AIR HAMMER DESIGNED BY MR. FREDERICK.

plex valve motions and the difficulty of making repairs to these. Finding the chief source of trouble with these hammers to be in the valves he set about making a hammer in which the work of the valve should be done by the piston itself. The result of his work is shown in the accompanying illustrations.

A glance at the line cut will show the internal parts of the tool. These consist only of a cylinder having ports in proper places and a solid piston with ports and annular grooves. This



AIR HAMMER DESIGNED BY MR. JOSEPH FREDERICK.

piston controls the admission and exhaust of air to and from the cylinder and the speed of the tool may also be governed by closing the exhaust ports with the hand.

An examination of the piston and the interior of the cylinder after the hammer had been used for some time disclosed no signs of wear, and this shows that piston must be perfectly balanced.

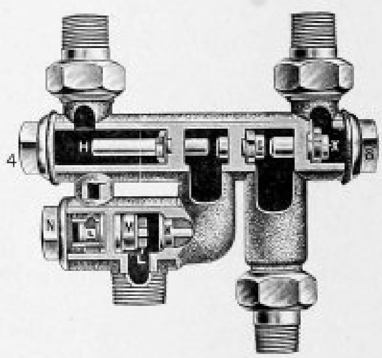
By further reference to the cut it will be noticed that the bushing at the end of the cylinder may be forced back into the cylinder, thus shortening the stroke and giving a much lighter blow.

As there are in this tool no parts subject to any very great amount of wear or liability to breakage it would seem that this tool is likely to fill a long-felt want, and especially is this true where hammers are used in places remote from repair shops.

Handling Hot Water with an Injector.

While a large majority of boilers carry less than 150 pounds pressure, there is an increased demand for an injector operating between 150 and 200 pounds pressure. There is also a demand for an injector that will handle a water supply that has become heated by use of the syphon (or ejector) and is consequently too hot for injectors of the usual automatic type.

In feeding a boiler with water over 120 degrees F. many users of steam experience a great deal of difficulty due largely to their failure to meet the necessary conditions. Consideration must be given to the fact that at a certain point on high steam pressure the condensing qualities of the water are not sufficient. Steam must be condensed before it can pass through the injector. For instance, at 180 pounds steam pressure, the same volume of feed water will not condense the steam that would be sufficient to condense the steam at 120 pounds pressure.



THE AUTO-POSITIVE PENBERTHY INJECTOR.

The higher the temperature of the feed water the less are its condensing qualities and vice versa.

These conditions and requirements have resulted in the production of the Auto Positive "Penberthy" Injector. This injector is constructed on new principles, having but five working parts and combining the features of a positive with those of an automatic injector. By this combination is it claimed that it will handle much hotter water and work on higher steam pressure than the ordinary type of automatic injector.

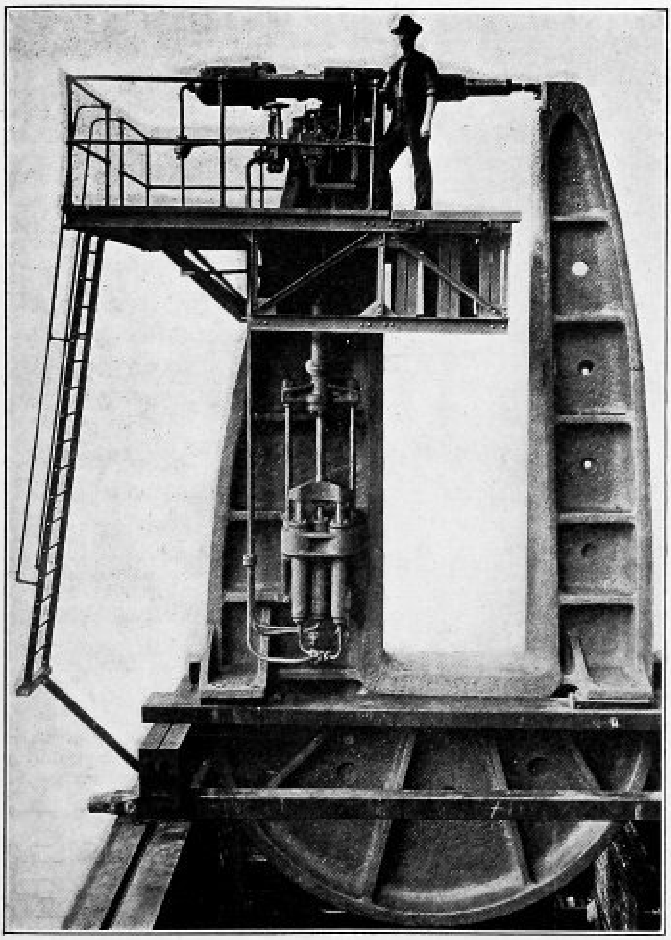
The details of this injector, which is manufactured by the Penberthy Injector Company, Detroit, Mich., are clearly shown in the sectional view of the apparatus.

A Seventeen-Foot Six-Inch Gap Hydraulic Riveter.

Experience has shown that for driving steel rivets and making them tight without calking a hydraulic riveter is one of the best machines which can be used. To meet the increasing demand for this type of riveter the Bethlehem Steel Company, Bethlehem, Pa., have added to their list of hydraulic machinery the 17-foot 6-inch gap riveter shown on this page.

Although the riveter is rated as having a gap of 17 feet 6 inches, the entire distance to the bottom of the gap is 17 feet 9 inches. The gap is 4 feet 6 inches wide. The riveter stake is a one-piece steel casting weighing 96,240 pounds, its extreme width being 14 feet, and the height from the bottom of the casting to the center of the plunger 26 feet. The greatest thickness of the casting is 5 feet 5 inches.

The ram may be operated under any one of six different pressures, having a travel of 8 inches in each case. The range of pressure is obtained by means of an intensifier, having five cylinders, three of which accommodate 2¾-inch diameter plungers, and two 3¼-inch diameter plungers. When the line pressure of 1,500 pounds per square inch is admitted to all five cylinders, the maximum pressure of 150 tons is exerted at the ram. By eliminating one small cylinder a pressure of 125 tons is obtained, and by cutting out two small cylinders 100 tons is obtained. The use of the large cylinders produces 75 tons, and of two small cylinders 50 tons. The regular line pressure of 1,500 pounds per square inch gives the minimum pressure of 25 tons on the ram.



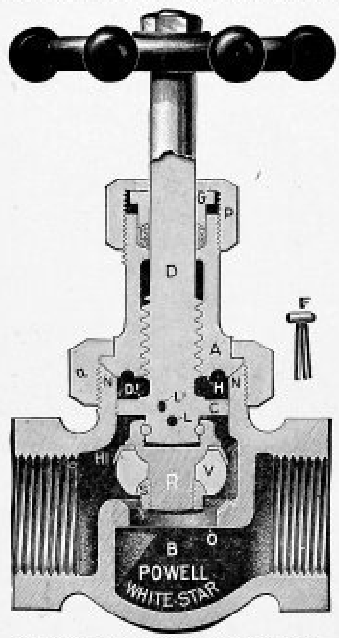
LARGE HYDRAULIC RIVETER.

The operation of the different cylinders is regulated by a "setting valve," leaving the motion of the ram under the control of a single lever. The arrangement of the valves, levers, operating platform, etc., is clearly shown in the photograph.

Valves and Valve Construction.

In these days of keen competition, when every manufacturer is daily increasing the output of his plant, necessitating greater steam power at higher pressure, the question of which valves will stand up under this pressure has become an important one. In the old days, when lower pressures were generally used, a valve of comparatively soft metal would give good service. To-day a valve must be capable of withstanding a much higher pressure and also a much higher temperature, due to the use of superheated steam.

A valve, for which good service is claimed under these conditions, is the Powell White Star Valve, which gets its name from the peculiar silver white metal used for its disc and seat. This metal has been given the name of "Powellium White Bronze." It has unusual wearing qualities and a high melting point (2,000 degrees F.). Another feature of this valve is found in the bonnet which is coned and ground to a bearing to fit the body neck and secured thereto by a Union nut, which makes an absolutely tight oint. Owing to the expanding thread of the beveled face of the bonnet upon the neck of the body shell, the tighter the coupling nut is wrenched down, the greater the expansion of the metal, and this makes it impossible to blow off the top rigging under heavy pressure. This is a decided departure from the old style of flat faced contact, in which the threads of the neck frequently collapsed, thereby loosening the nut and inviting a disastrous blow off.



THE POWELL WHITE STAR VALVE.

The discs have duplicate wearing faces, and are screwed to the revolving carrier and protected by a flange on the upper and inside faces until the lower face is worn out. They may then be reversed and the valve is ready for new life. Thus, marked economy is claimed for this valve, as practically the only part which can wear out, namely, the disc, is not only constructed of a special metal of unusual wearing qualities, but it is reversible, and after both faces are worn out can be easily replaced by a new one.

The disc (which is removable) is attached to the holder *R* by jam nut *S*, which holder swivels on the stem and is covered with flange *H I* to protect the upper face of the disc from scale or corrosion while the lower face is in service. The stem

D is centrally guided within the neck *N* of the body *B* by wing guides *C*. The valve stem *D* is pierced at *L* to receive the lock bar *F* when locking the disc *V* for grinding. When the lock bar *F* is not in use it is placed in the hole *L I*, between wings *C*, and as this part never leaves the inside bearing surface of the neck *N*, it is impossible for the bar to be lost.

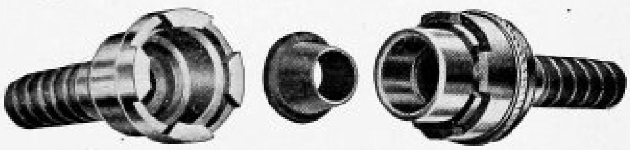
The bonnet *A* is firmly screwed to the cone face of the body neck *N* by coupling nut *a*, and the tighter this is screwed down, the tighter the grip expands the threads of the neck, making it impossible to blow off the top rigging under the heaviest pressure. The wing guides *C* tend to secure a perfect alinement of both stem and disc, thus greatly prolonging the life of the valve. All the Powell White Star valves are packed with a drive gland *G*, and valves with removable seat rings have the extra long drive gland which projects through the packing cap *P*. The packing is of suitable material to resist the high temperatures of superheated steam. The valve is provided with its own lock bar for regrinding.

The White Star Valve and Engineering Specialties can be procured direct from the Wm. Powell Company, Cincinnati, Ohio.

Dallett Automatic Hose Coupling.

The Thos. H. Dallett Company, of Philadelphia, Pa., has made a continuous series of experiments and tests on hose couplings for the past four years, with the result that they have now perfected and placed upon the market the "Dallett" hose-to-hose coupling shown in the illustration.

The gasket of the "Dallett" coupling is of a rubber composition, which will not be affected by oil or gasoline, and is held in the female half by the flange around the larger end fitting into a recess. It is claimed that it is impossible for this



THE DALLETT HOSE COUPLING AND GASKET.

gasket to fall out and become lost when the coupling is disconnected, and that, when necessary, a new gasket can be inserted in a few seconds. When the coupling is connected, the tapering end of the gasket enters into the conical opening in the male part, forming only a loose fit. When pressure comes on the coupling this tapered end of the gasket is expanded against the wall of the conical opening, making a perfect joint, which greater pressure will only make tighter, and as soon as the pressure is relieved the gasket is again loose, so that no matter how long a coupling may remain connected the gasket will not adhere to the metal and be torn and ruined when the coupling is taken apart.

As will be noted, the male part of the coupling is provided with four locking-lugs, equally spaced around its circumference, so that when the male and female parts are snapped together, these lugs insure their being held squarely, thus minimizing the tendency to leak. To connect the coupling, simply press the parts together, give one-eighth of a turn and the locking-ring will spring into place. When the connection is to be broken, again it is only necessary to press back the locking-ring and give the coupling one-eighth of a turn.

The entire coupling is made of a very hard bronze composition, has no small parts to give trouble, and no projecting pieces to catch when the hose is trailed along the ground. The locking-ring is provided with a milled ridge around its circumference, which affords a good grip for pressing it back when disconnecting the coupling, and so stiffens and strengthens it that it requires extraordinary abuse to spring or bend it so as to impair the working of the coupling.

SELECTED BOILER PATENTS.

Compiled by
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Washington, D. C.

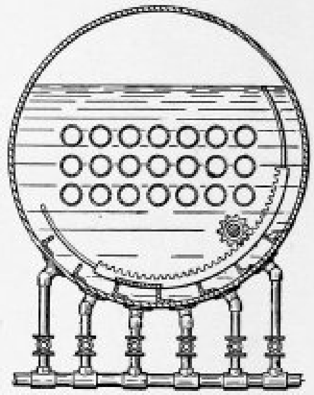
Readers wishing copies of patent papers, or any further information regarding any patent described, should correspond with Mr. Decker.

847,387. SYSTEM OF WASHING AND FILLING LOCOMOTIVE BOILERS. William White, of Chicago, Ill.

Claim.—A locomotive boiler washing and filling system, comprising a washout and filling water supply reservoir, means for automatically regulating the temperature of the water therein, means for distributing the water from the supply-tank, and further means for regulating the temperature of the distributed water. Eight claims.

858,304. BOILER CLEANER. Lafayette M. Pettit, of Cripple Creek, Col.

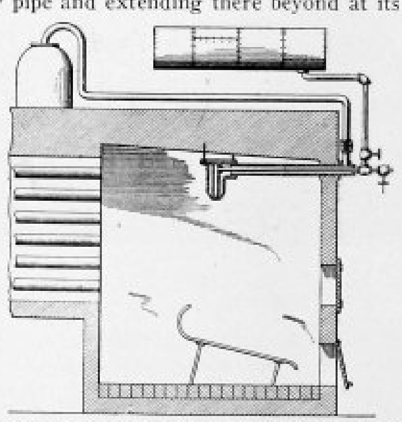
Claim.—In a boiler cleaner, the combination with a boiler provided with a number of channels formed in its lower portion, a plate for closing said channels separately, means for manipulating the plate from the exterior of the boiler whereby



the said plate is caused to close any desired channel, one extremity of the channel being in communication with the boiler, while the other is provided with a discharge outlet. Four claims.

859,128. OIL BURNER. Charles E. Swenson, of Charlie, Tex.

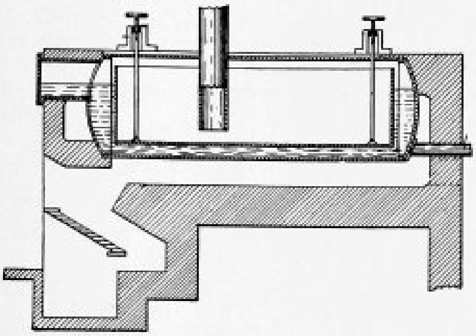
Claim.—The combination with a furnace, of a fluid supply pipe extending thereinto at the top thereof; a boiler mounted upon the top of said furnace and connected with the outer end of said supply pipe; an oil supply pipe arranged within said fluid supply pipe and extending there beyond at its outer end;



a plate secured to the inner face of the furnace top and provided with depending outer and inner nozzles formed integral therewith and arranged in spaced relation to each other, said outer nozzle being in communication with said fluid supply pipe and said inner nozzle with said oil supply pipe; an inclined plate mounted upon the furnace bottom directly beneath said nozzles, said furnace having a draft opening formed in one of its side walls in line with said inclined plate; a salt-water tank mounted above the top of the furnace; and a pipe connection between said tank and the outer end of said oil supply pipe, to admit salt water into the latter simultaneously with the oil.

859,271. STEAM BOILER. Charles G. Wieland, of Hoboken, N. J.

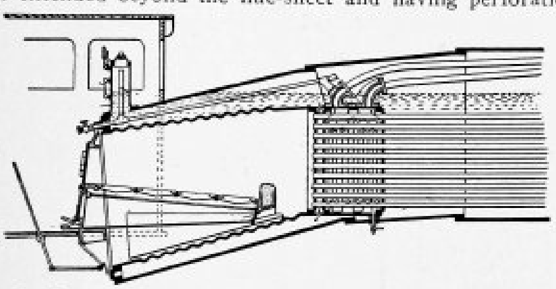
Claim.—The combination with a boiler, of a hollow member therein adapted for storing the steam of said boiler, and means



adapted to adjust the position of said hollow member in said boiler, irrespective of the water actually contained therein. Six claims.

859,561. SUPERHEATER FOR STEAM BOILERS, Oscar Illi, of Schenectady, N. Y.

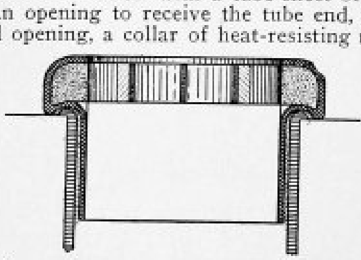
Claim.—In a steam boiler, the combination with the fire-box shell extended beyond the flue-sheet and having perforations



near the flue-sheet, of a superheater in said extension and traversed by the fire tubes, and a water chamber in said extension at the rear of the superheater for communicating with the boiler through said perforation. Six claims.

860,008. BOILER-TUBE JOINT. Hans Auerbach, of Dresden, Germany.

Claim.—The combination with a tube-sheet of a boiler provided with an opening to receive the tube end, of a tube secured in said opening, a collar of heat-resisting material fitted



into the end of the tube and provided with a hollow lip of greater diameter projecting over the joint on the outside of the tube sheet having radial partitions forming cells, cementitious material in said cells, and similiar material between the tube and collar. One claim.

846,213. BOILER CHECK VALVE. Leopold Kassander, of New York, N. Y., assignor to Nathan Manufacturing Company, of New York.

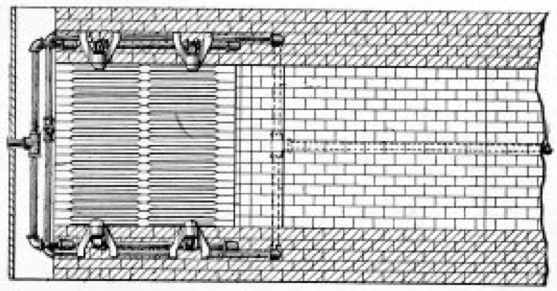
Claim.—In a double boiler check valve, a valve-body divided vertically into two distinct and separate series of three superposed communicating chambers—a primary chamber below, an intermediate chamber and a check valve chamber above—a check valve in the intermediate chamber accessible through a cap-closed lateral opening in the walls of said chamber, a check valve in the check valve chamber accessible through a cap-closed opening in the top of the valve-body, a delivery-chamber common to and communicating with the check valve chambers of each series, and a separate stop-valve for controlling communication between the delivery chamber and each check valve chamber. Two claims.

860,211. GRATE. Peter B. Hartford, of New York, N. Y.

Claim.—A grate having disks supported upon bars, the said bars being rotatable and the said disks being circular, with teeth thereon, the said disks being additionally supported by rollers which are serrated, whereby the disks will be shaken and jarred when rotated. Four claims.

860,077. BOILER-FURNACE. Howard H. Benn, of Columbus, Ohio, assignor, by direct and mesne assignments, of forty-five one-hundredths to William Turpie, of Columbus, Ohio, and Francis B. De Witt, of Au Gres, Mich.

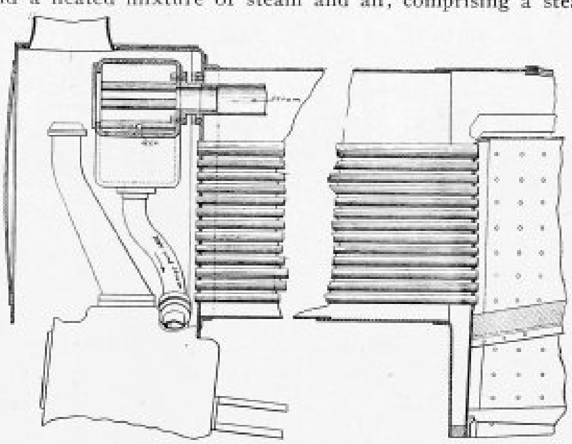
Claim.—In a boiler furnace, the combination with a steam superheating coil arranged in the wall of the furnace, of nozzles having connection with the coil for directing sprays of



superheated steam upon the fire, said nozzles projecting through the wall of the furnace and entirely filling the openings through which they project, casings partially surrounding said nozzles, and an air supply pipe leading to said casings, said air supply pipe being open at one end to the atmosphere and open at the other end to the ash pit of the furnace. Two claims.

860,455. LOCOMOTIVE AND OTHER ENGINE USING A MIXTURE OF AIR AND STEAM AS A MOTIVE FLUID. Edward Field, of London, Eng., assignor to the New Century Engine Company, Ltd., of London.

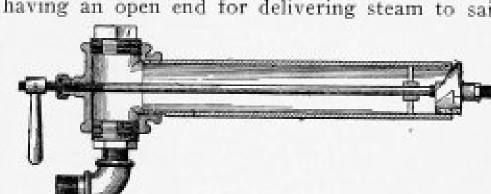
Claim. Apparatus for preparing and applying as motive fluid a heated mixture of steam and air, comprising a steam



boiler, a smoke box through which hot gases from the boiler furnace pass, a mixing and heating chamber located in the upper part of said smoke box so as to be heated by the furnace gases passing therethrough, means for conveying hot gases from the boiler furnace to the smoke box adjacent to said mixing and heating chamber at a temperature higher than that of the gases ordinarily passing to the smoke box, means for supplying steam from the boiler to said chamber, means for supplying air under pressure to said chamber, and an engine to which the heated mixture of steam and air is supplied from the said chamber. Twenty-eight claims.

861,350. STEAM-FLUE CLEANER OR BLOWER. James C. Bennett, of Detroit, Mich.

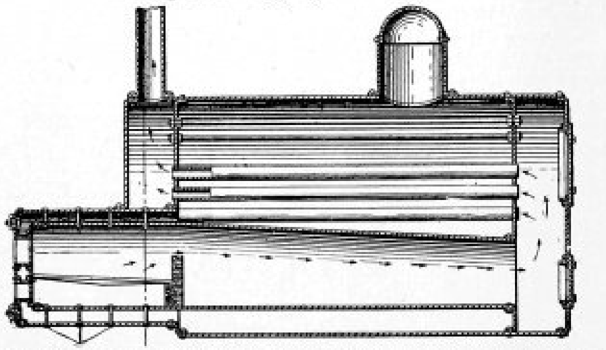
Claim.—In a flue cleaner, the combination with a tubular body having an open end for delivering steam to said body,



of means within the open end of said body adapted to form therewith a discharge opening of varying angle between said means and the body and adapted to be adjusted into and out of said end to vary said opening. Nine claims.

860,538. STEAM-BOILER. Peter C. Forgard, of Lake Preston, S. D.

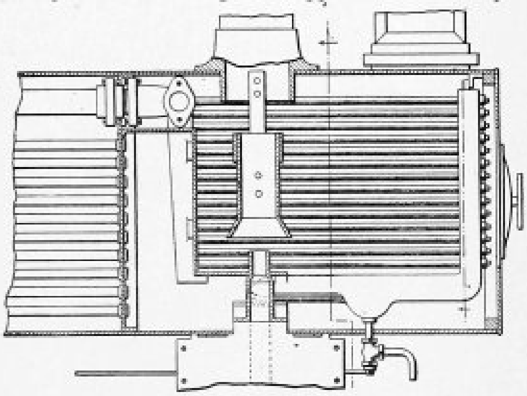
Claim.—The combination with a boiler having a combustion chamber at one end and a smoke chamber at the opposite end, of a shell extending outwardly beyond the smoke chamber and



inwardly to and communicating with the combustion chamber, a bridge wall and grate arranged in the outwardly extending end portion of the shell, and a plurality of fire tubes connecting the combustion chamber and the smoke chamber. One claim.

861,137. SUPERHEATER. Sweney Munson, of Fowler, Col.

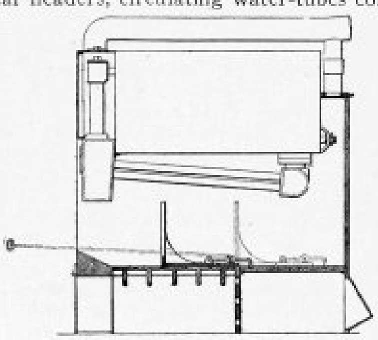
Claim.—A superheater comprising similar sections spaced apart, adapted to be arranged on opposite sides of a petticoat



pipe, each having headers provided with inner and outer end walls, and steam pipes connecting the inner walls of said headers. Nine claims.

861,167. HEATING BOILER. Henry P. J. Earnshaw, of Hyde Park, Mass.

Claim.—In a boiler, a horizontal boiler-shell having flues extending therethrough, horizontal transversely extending front and rear headers, circulating water-tubes connecting said



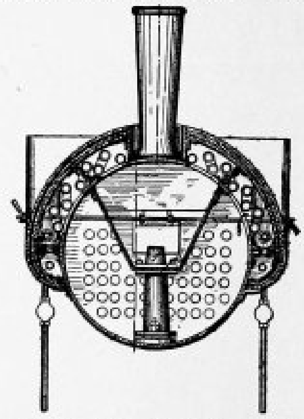
headers, connections between each other and the boiler-shell, a smoke-chamber at both the front and the rear end of the boiler-shell, each smoke-chamber being connected to the smoke-flue, and a damper controlling the connection between the rear smoke chamber and said flue. Six claims.

861,784. GRATE. Alfred B. Willoughby, of Philadelphia, Pa.

Claim.—A grate, consisting of a series of rings concentrically arranged with respect to each other, means for loosely and removably supporting and holding the rings defined distances apart, means connected with said supporting means to permit of an oscillating movement of the same and of the rings carried by said support in a vertical planes and means carri by said support for separately or conjointly rotating t even and odd numbered rings therein. Six claims.

861,667. FEED-WATER HEATER. Sylvester A. Morga of Indianapolis, Ind.

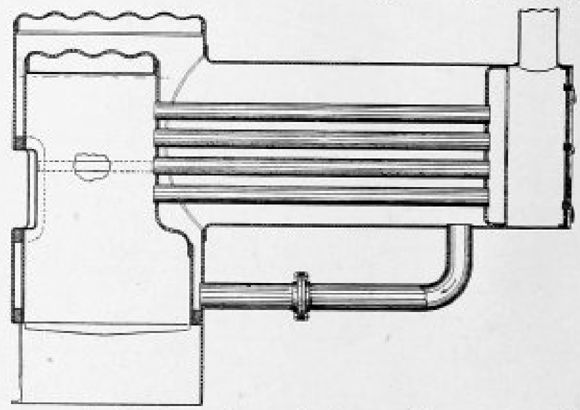
Claim.—In a locomotive feed-water heater, the combinati with a locomotive boiler having a front smoke arch and a pa tition wall dividing said smoke arch into upper and low



compartments, said partition provided with a door-way, and door hinged over said door-way, of return flue-ways arrange exterior of the boiler to be connected to said lower and upp compartments of said smoke arch, and feed-water heatin pipes arranged to extend longitudinally of each of said retur flue-ways. Three claims.

863,829. BOILER. George C. Andrews, of Minneapoli Minn.

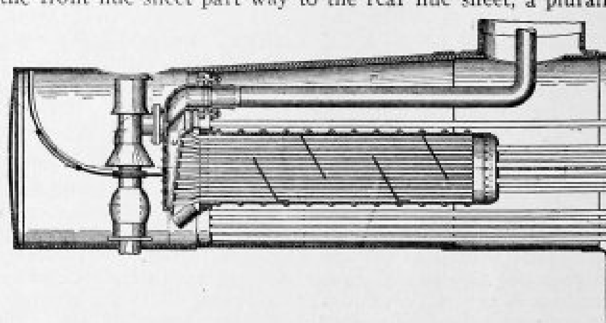
Claim.—A boiler of the locomotive type having a deflectin



ring extended horizontally at the intermediate portion of it vertical water compartment. Two claims.

863,333. LOCOMOTIVE BOILER AND STEAM SUPER HEATER. Henry H. Vaughan, of Montreal, Quebec, Can.

Claim.—Improvements herein described, comprising a fir tube boiler, its fire-box and smoke-box, in combination with shell of less diameter than the boiler, the same extending fro the front flue sheet part way to the rear flue sheet, a pluralit



of flues extending from said rear flue sheet into the rear en of said shell, saturated and superheated steam headers pro vided in said smoke-box at the open end of said shell and group of loop pipes occupying said shell and connected wit said headers. Eleven claims.

THE BOILER MAKER

VOL. VII NOVEMBER, 1907 No. 12

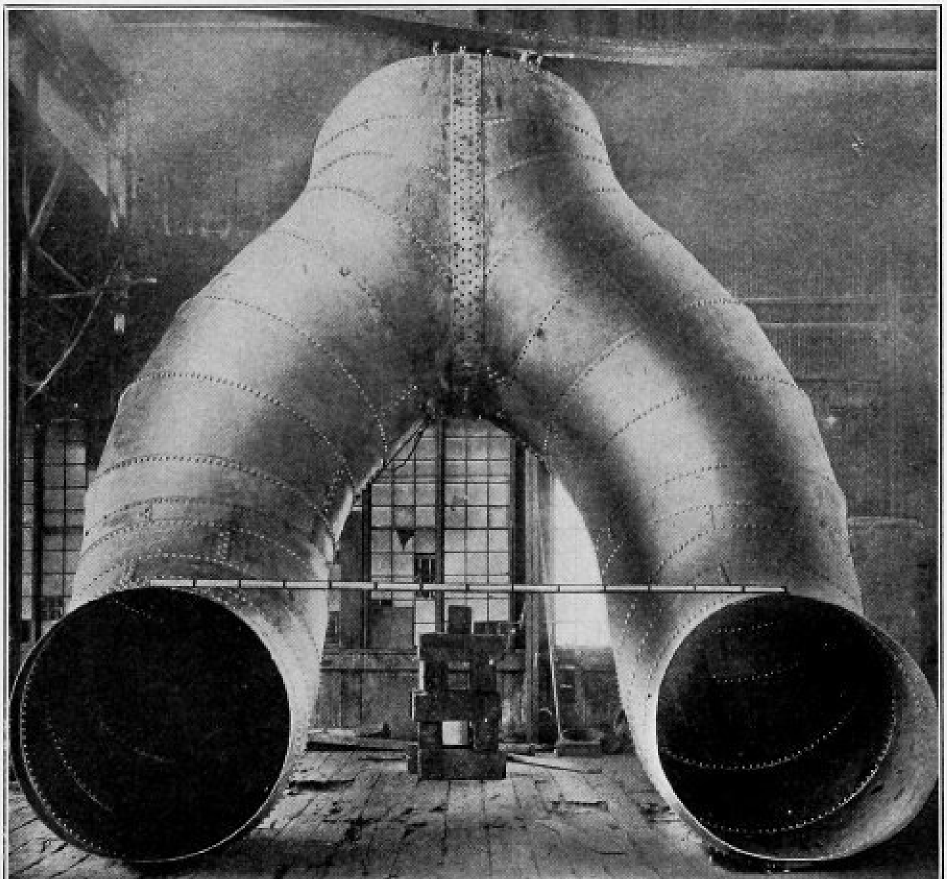
LAYOUT OF A LARGE "Y" CONNECTION.

BY EMMET S. HEGERTY.

In presenting to the readers of THE BOILER MAKER the layout of the large "Y" connection shown on this page, the writer realizes that it represents a class of work that probably never comes up in many boiler shops. Work of this kind, however, may come up at any time in large contract shops.

Before starting to lay out a job of this kind, especially when it is as large and made of as heavy material as was used in to hammer them to shape and make them fit accurately.

This "Y" connection, as will be seen by referring to the elevation (Fig. 1), is composed of taper elbows, which meet on a 50-degree angle, the upper elbows being cut off at their intersection at right angles with the top at the center of the top course. The layout is not shown for the lower elbows, which appear in the photograph of the finished connection, as



VIEW OF THE COMPLETED PENSTOCK. THE DIAMETER OF THE LARGE PIPE IS 9 FEET, OF THE SMALL PIPES 6 FEET.

this "Y" connection, the layer-out should figure out the easiest manner in which it can be handled by the workmen in the shop. He should also see that those who roll or fit the work do it in accordance with the method he employed in laying it out. This is especially important in rolling or pressing heavy plates that have been laid out by triangulation, because, if they have not been properly pressed or rolled, you cannot expect a fitter this layout would be only a duplicate of that shown in Fig. 7.

In drawing the elevation of the "Y," the writer made a few changes in the top portion of the connection that made it easier to fit up and did not alter the measurements. By referring to the elevation it will be noticed that the upper portion is not a true cone, the short side of the top course being at right angles with the top. This was done in order to lessen the acuteness

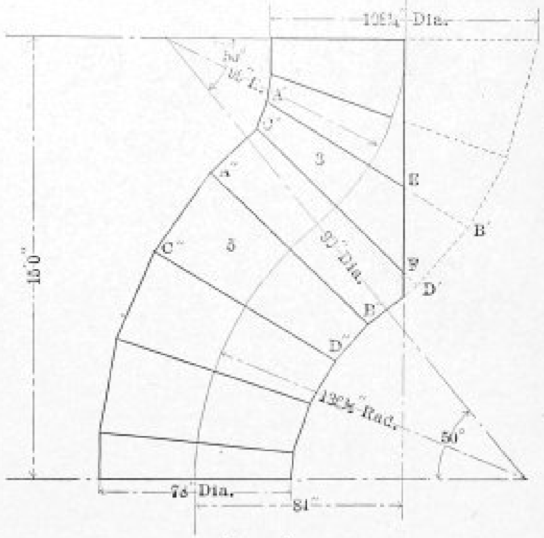


Figure 1

ELEVATION OF THE CONNECTION.

of the angle at the girth seams, between the first and second courses, making a more practical job and one which is far more easy to fit.

Triangulation was used on this job throughout and was found to be very accurate. Many layers-out still hold to projection in laying out taper elbows, and while this method may be "near enough" in small work it is absolutely no good in work of this kind, because "good enough" is not the best if it is not correct. Projection, when used in laying out sketch plates that are 25 feet or more in length, with the guess work used in trying to get the proper taper or camber, is far from being correct.

In drawing the plans of the different courses for performing the triangulation, the writer assumed both ends to be perfectly round. When the sheets were rolled or pressed, they were done so in a manner that made them conform to this layout. This eliminated the use of two developed circles representing the shape of the ends and saved considerable work.

In laying out work of this kind be accurate in your measurements. This is very important. The writer has endeavored to make the layout as clear as possible, and in order not to confuse the figures the scale of the drawings showing the layout of the individual courses has been increased, and therefore the measurements of Figs. 2-7 do not conform to those of the elevation, Fig. 1. This was necessary owing to the slight taper of the different courses.

Fig. 1 represents the elevation of one-half the upper portion of the "Y," the elbow forming the lower portion being unnecessary. As the layout for the first three courses would be similar, the layout is given for but one. We will select course marked

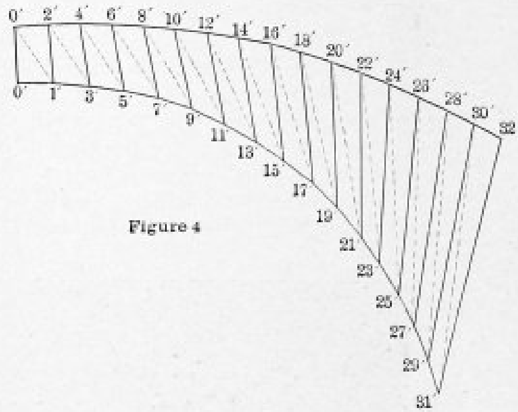
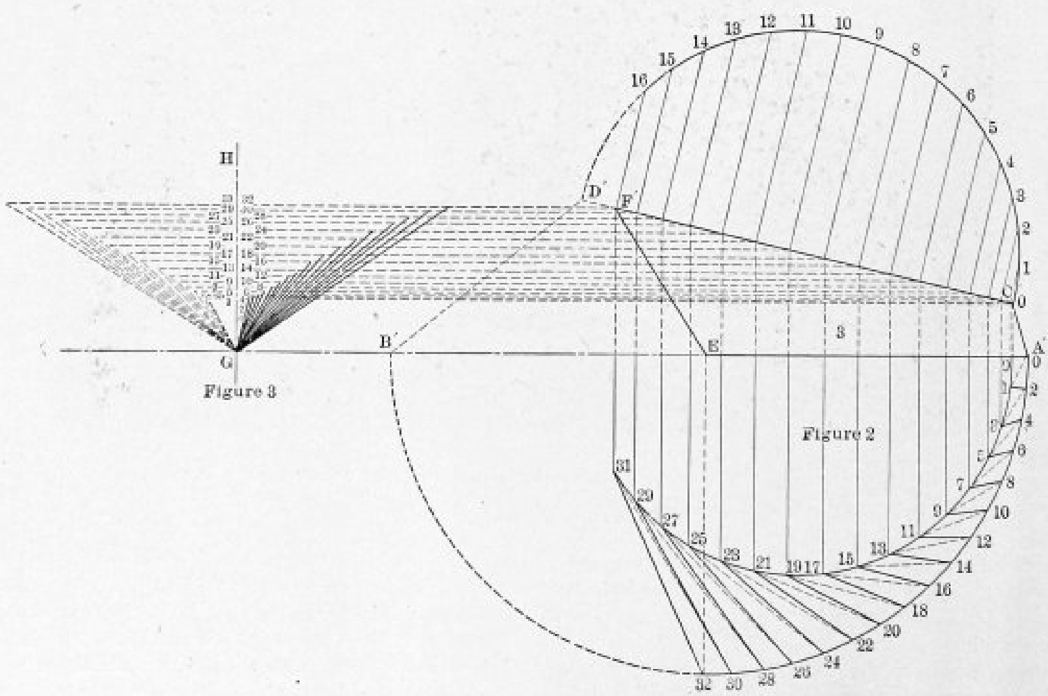


Figure 4

HALF PATTERN OF SECTION 3.

(3) in the elevation to show the method used in laying out the plates that make the crotch of the "Y."

In Fig. 2 make the lines *A'-B'-C'-D'-E'* and *F'* equal in length to corresponding lines of the elevation. From the center of *C' D'* draw a circle equal in diameter to *C D* of the elevation. From the point *F'* draw a line at right angles to *C' D'* intersecting the circle, this point of intersection being the point where the small end of this plate butts with a corresponding plate of the other half of the "Y." This portion of the circle is divided into any number of parts, in this case sixteen (16),



ENLARGED VIEW OF SECTION 3, SHOWING WORK OF TRIANGULATION.

and from these points lines are drawn intersecting the line $C' D'$ at right-angles.

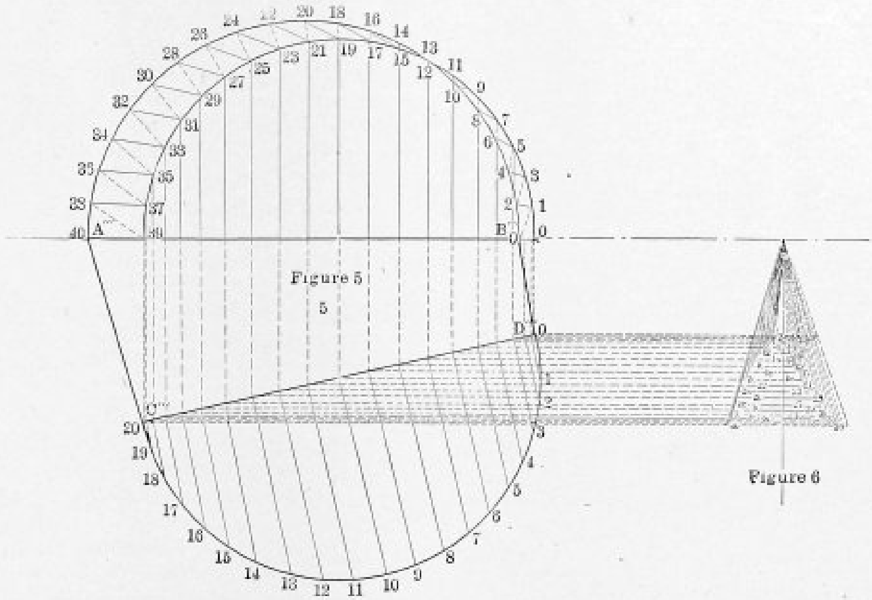
It is necessary to get a view of this pipe (or course) looking into it at right-angles with the line $A' B'$. In order to obtain a correct view of the small end, looking at it thus, continue indefinitely the lines just drawn at right-angles with the line $A' B'$. Upon these lines establish points at a distance from $A' B'$ equal to the distance of the corresponding points on the circle from $C' D'$. A line traced through the points thus established gives the desired view as shown.

From the center of the line $A' B'$ draw a circle equal in diameter to $A B$ of the elevation. From the point E' draw a line at right-angles to the line $A' B'$ until it intersects the circle. This will be the point where the large end of the plate butts with a corresponding plate of the other half of the "Y." Divide this portion of the circle into the same number of parts as the other circle, namely, sixteen (16). Connect these points with lines forming the triangles, as shown in Fig. 2.

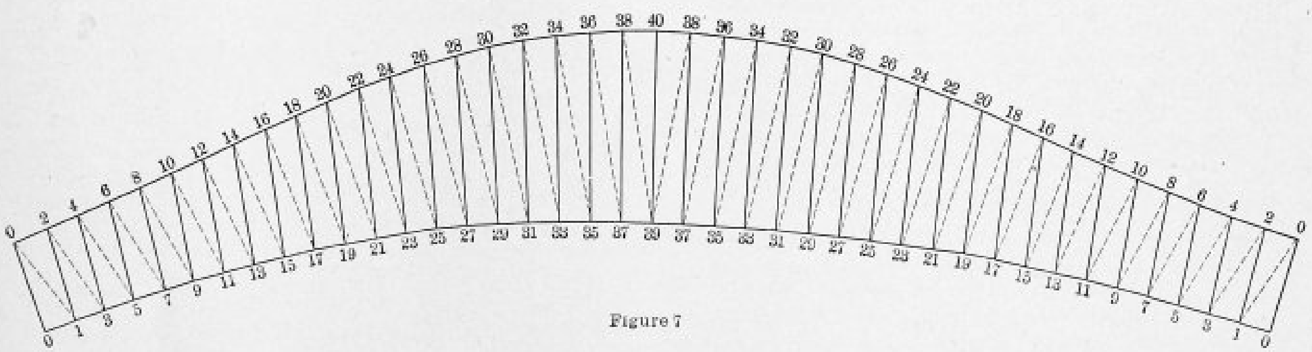
In order to obtain the true lengths of the lines forming the triangles it is necessary to obtain their straight heights. These are obtained as follows: Erect a line at right-angles to the line $A' B'$, as $G H$ of Fig. 3. From the points where the several lines used in the view of the small end intersect the line $C' D'$ of Fig. 2, draw lines at right-angles to the line $G H$, continuing them beyond the line $G H$. The distance from G to the points where these lines intersect the line $G H$ represents the straight height of the different triangles. Upon these lines, with the line $G H$ as a center, set off distances equal in length to the length of the dotted and solid lines of the plan of Fig. 2. The distance from G to the several points being the true length of the different lines forming the triangles.

We are now ready to lay out the pattern. Draw a line as $O' O''$, Fig. 4, making it equal in length to the distance from G to O, Fig. 3. With the dividers set the same as they were in dividing the circle of the small end, and using O'' as a center, draw an arc. From O' as a center with the dividers set equal to the distance from G to 1, Fig. 3, draw an arc, intersecting the arc previously drawn from O''. This establishes the point 1' of Fig. 4.

With the dividers set as they were in dividing the circle of the large end of Fig. 2, using O' as a center, draw an arc. From 1' as a center, with dividers set equal in length to the distance from G to 2, Fig. 3, draw another arc intersecting the arc previously drawn from O'. This establishes the point 2'. The balance of the pattern is obtained in the same manner until completed, as shown in Fig. 4. The pattern for the elbow plate is obtained in the same manner, and the writer does not consider it necessary to explain this in detail but shows the layout for reference.



PLAN AND ELEVATION OF SECTION 5, SHOWING DETAILS OF TRIANGULATION.



COMPLETED LAYOUT OF SECTION 5.

The reader's attention is called to the fact that the length of the wide end of the pattern shown in Fig. 4 is not equal to the length of the wide end of the course as shown in the elevation. By referring to the plan of this course, as shown in Fig. 2, the reason is readily seen. It will also be noticed that owing to the shape of the pattern for this plate, in order to make it have its true shape, it would be impossible to roll it, hence this plate, as well as the others that form the crotch of the "Y," should be pressed.

It will also be noticed by referring to the cut showing the finished "Y" that the seams are off center. The seams are not shown off center in the layout, as this can be easily adjusted by the layer-out. Also no allowances have been made for laps. To avoid a great amount of adjusting, it is a good plan in laying out work of this nature, where the sheets are so large, for the layer-out to figure the diameters of the ends of the courses to the center of the thickness of the metal—the same as you do when figuring the circumference of any plate. Then when the triangles are spaced the plate will be of the correct size, and it will not be necessary to adjust the points for a fit.

This "Y" connection was made of ½-inch, 7/16-inch and ⅜-inch material, and when finished was as nearly correct as it is possible to get work of this nature. The plates forming the crotch required flanging in order to make a flat surface for the butt straps. This work required special care, so that the flange would stand at the proper angle and form a flat surface for the butt straps.

In any job of triangulation be sure that your measurements are correct, for if the drawings are correctly made anything in this line of work can be laid out by this method and you will find your work will be correct. Study your work before you start, so that you will know what you are trying to do before you draw your plans and everything will work out satisfactorily.

Rules for Boiler Inspection.

Formulated by the Massachusetts Board of Boiler Rules.

Maximum Pressure on Boilers.

The maximum pressure allowed on any steam boiler constructed wholly of cast iron shall not be greater than twenty-five (25) pounds to the square inch.

The maximum pressure allowed on any steam boiler, the tubes of which are secured to cast-iron headers, shall not be greater than one hundred and sixty (160) pounds per square inch.

The maximum pressure allowed on any steam boiler constructed of iron or steel shells or drums shall be calculated from the inside diameter of the outside course, the percentage of strength of the longitudinal joint and the minimum thickness of the shell plates; the tensile strength of shell plates to be taken as fifty-five thousand (55,000) pounds per square inch for steel and forty-five thousand (45,000) pounds per square inch for iron, when the tensile strength is not known.

Shearing Strength of Rivets.

The maximum shearing strength of rivets per square inch of cross-section of area to be taken as follows:

	Pounds.
Iron rivets in single shear...............	38,000
Iron rivets in double shear...............	70,000
Steel rivets in single shear...............	42,000
Steel rivets in double shear..............	78,000

Factors of Safety.

The lowest factors of safety used for steam boilers, the shells or drums of which are directly exposed to the products of combustion and the longitudinal joints of which are of lap-riveted construction, shall be as follows:

(*a*) Five (5) for boilers not over ten years old.

(*b*) Five and five-tenths (5.5) for boilers over ten and not over fifteen years old.

(*c*) Five and seventy-five hundredths (5.75) for boilers over fifteen and not over twenty years old.

(*d*) Six (6) for boilers over twenty years old.

(*e*) Five (5) on steam boilers, the longitudinal joints of which are of lap-riveted construction, and the shells or drums of which are not directly exposed to the products of combustion.

(*f*) Four and five-tenths (4.5) on steam boilers, the longitudinal joints of which are of butt and strap construction.

Fusible Plugs.

Fusible plugs, as required by section 20, chapter 465, Acts of 1907 (No person shall use, or cause to be used, a steam boiler, excepting boilers upon motor road vehicles, steam fire engines, boilers in private residences, or boilers under the jurisdiction of the United States, unless it is provided with a fusible safety plug made of lead or some other equally fusible material, as specified by the rules to be established by the board of boiler rules), shall be filled with pure tin.

The least diameter of fusible metal shall not be less than one-half (½) inch, except for working pressures of over one hundred and seventy-five (175) pounds gage, or when it is necessary to place a fusible plug in a tube, in which cases the least diameter of fusible metal shall not be less than three-eighths (⅜) inch.

The location of fusible plugs shall be as follows:

(*a*) In Horizontal Return Tubular Boilers.—In the back head, not less than two (2) inches above the upper row of tubes, and projecting through the sheet not less than one (1) inch.

(*b*) In Horizontal Flue Boilers.—In the back head, on a line with the highest part of the boiler exposed to the products of combustion, and projecting through the sheet not less than one (1) inch.

(*c*) In Locomotive Type or Star Water-Tube Boilers.—In the highest part of the crown sheet, and projecting through the sheet not less than one (1) inch.

(*d*) In Vertical Fire-Tube Boilers.—In an outside tube, placed not less than one-third (1/3) the length of the tube above the lower tube sheet.

(*e*) In Vertical Submerged Tube Boilers.—In the upper tube sheet.

(*f*) In Water-Tube Boilers, Horizontal Drums, Babcock & Wilcox Type.—In the upper drum, not less than six (6) inches above the bottom of the drum, and over the first pass of the products of combustion, projecting through the sheet not less than one (1) inch.

(*g*) In Stirling Boilers, Standard Type.—In the front side of the middle drum, not less than six (6) inches above the bottom of the drum, and projecting through the sheet not less than one (1) inch.

(*h*) In Stirling Boilers, Superheater Type.—In the front drum, not less than six (6) inches above the bottom of the drum, and exposed to the products of combustion, projecting through the sheet not less than one (1) inch.

(*i*) In Water-Tube Boilers, Heine Type.—In the front course of the drum, not less than six (6) inches above the bottom of the drum, and projecting through the sheet not less than one (1) inch.

(*j*) In Robb-Mumford Boilers, Standard Type.—In the bottom of the steam and water drum, twenty-four (24) inches from the center of the rear neck, and projecting through the sheet not less than one (1) inch.

(*k*) In Water-Tube Boilers, Almy Type.—In a tube directly exposed to the products of combustion.

(*l*) In Vertical Boilers, Climax or Hazelton Type.—In a tube or center drum not less than one-half (½) the height of the shell, measuring from the lowest circumferential seam.

(*m*) In Cahall Vertical Water-Tube Boilers.—In the inner sheet of the top drum, not less than six (6) inches above the upper tube sheet.

(*n*) Scotch Marine Type Boilers.—In combustion chamber top, and projecting through the sheet not less than one (1) inch.

(*o*) In Dry Back Scotch Type Boilers.—In rear head, not less than two (2) inches above the top row of tubes, and projecting through the sheet not less than one (1) inch.

(*p*) In Economic Type Boilers.—In the rear head above the upper row of tubes.

(*q*) In Cast-Iron Sectional Heating Boilers.—In a section over, and in direct contact with, the products of combustion in the primary combustion chamber.

(*r*) For other types and new designs, fusible plugs shall be placed at the lowest permissible water level, in the direct path of the products of combustion, as near the primary combustion chamber as possible.

Size of Rivets.

When the size of the rivets in the longitudinal joints of a boiler is not known, the diameter and cross-sectional area of rivet, after driving, shall be taken as follows:

Thickness of plate	1/4"	9/32"	5/16"	11/32"	3/8"
Diameter of rivet after driving....	11/16"	11/16"	3/4"	3/4"	3/4" up to 2" pitch.
Cross-sectional area of rivet after driving...	.3712 sq. in.	.3712 sq. in.	.4418 sq. in.	.4418 sq. in.	.4418 sq. in.

Thickness of plate............	3/8"	13/32"	7/16"	7/16"
Diameter of rivet after driving	13/16" over 2" pitch.	13/16"	7/8" up to 2 1/4" pitch.	15/16" over 2 1/4" pitch.
Cross-sectional area of rivet after driving................	.5185 sq. in.	.5185 sq. in.	.6013 sq. in.	.6903 sq. in.

Thickness of plate............	15/32"	1/2"	9/16"	5/8"
Diameter of rivet after driving	15/16"	15/16"	1 1/16"	1 1/16"
Cross-sectional area of rivet after driving................	.6903 sq. in.	.6903 sq. in.	.8866 sq. in.	.8866 sq. in.

Allowable Strain on Stays.

The maximum allowable strain per square inch net cross-section for weldless mild steel stays shall be as follows:

TYPE.	Size up to and Including 1 1/2" Diameter or Equivalent.	Size Over 1 1/2" Diameter or Equivalent.
Head to head or through stays..............	8,000 lbs.	9,000 lbs.
Diagonal or crowfoot stays..................	7,500 lbs.	8,000 lbs.
Screwed stays (stay-bolts)..................	7,000 lbs.	7,000 lbs.

For welded stays the strain allowed per square inch net cross-section shall not exceed six thousand (6,000) pounds.

For wrought iron stays or stay-bolts the strain allowed per square inch net cross-section shall not exceed six thousand (6,000) pounds.

Appendages to be Placed on Boilers.

Each boiler shall have a safety valve the minimum area of which shall be in accordance with the following tables. If more than one safety valve is used the minimum combined area shall be in accordance with the following tables.

When the conditions exceed those on which the tables are based the formula shall be used.

A table of areas of grate surface in square feet for pop safety valves follows:

$$A = \frac{W\ 70}{P} \times 11$$

A = Area of safety valve in square inches per square foot of grate
W = Weight of steam per second.
P = Pressure, absolute.

		$W = \frac{75}{3600}$ P = 40 A = .401	$W = \frac{100}{3600}$ P = 65 A = .329	$W = \frac{160}{3600}$ P = 115 A = .297	$W = \frac{160}{3600}$ P = 140 A = .244	$W = \frac{200}{3600}$ P = 190 A = .224	$W = \frac{240}{3600}$ P = 240 A = .213
Gage pressure per square inch at which safety valve is set to blow.		Zero to 25 pounds.	Over 25 to 50 pounds.	Over 50 to 100 pounds.	Over 100 to 150 pounds.	Over 150 to 200 pounds.	Over 200 pounds.
Diameter of Valve in Inches.	Area of Valve in Square Inches.	Area of Grate in Square Feet.					
1	.7854	2.0	2.4	2.7	3.2	3.5	3.7
1 1/4	1.2272	3.1	3.8	4.2	5.0	5.5	5.7
1 1/2	1.7671	4.5	5.4	6.0	7.2	7.9	8.3
2	3.1416	7.9	9.6	10.6	12.9	14.0	14.8
2 1/2	4.9087	12.3	15.0	16.5	20.0	21.9	23.0
3	7.0686	17.6	21.3	23.8	29.0	31.5	33.2
3 1/2	9.6211	24.0	29.3	32.4	39.4	42.9	45.2
4	12.5660	31.4	38.2	42.3	51.5	56.0	59.0
4 1/2	15.9040	40.0	48.4	53.5	65.0	71.0	74.7
5	19.6350	49.0	60.0	66.0	80.0	88.0	92.1

A table of grate areas in square feet for safety valves (other than pop safety valves) follows; this table is in ratio to the table for pop safety valves as 2 is to 3:

Gage pressure per square inch at which safety valve is set to blow.		Zero to 25 pounds.	Over 25 to 50 pounds.	Over 50 to 100 pounds.
Diameter of Valve in Inches.	Area of Valve in Square Inches.	Area of Grate in Square Feet.		
1	.7854	1.4	1.6	1.8
1 1/4	1.2272	2.1	2.5	2.8
1 1/2	1.7671	3.0	3.6	4.0
2	3.1416	5.3	6.4	7.1
2 1/2	4.9087	8.2	10.0	11.0
3	7.0686	11.7	14.2	16.0
3 1/2	9.6211	16.0	19.5	21.6
4	12.5660	21.0	25.5	28.2
4 1/2	15.9040	26.7	32.3	36.0
5	19.6350	32.7	40.0	44.0

Each safety valve must have full-sized direct connections to the boiler, and full-sized escape pipe, which shall be fitted with an open drain to prevent water lodging in the upper part of safety valve or escape pipe. When a boiler is fitted with two safety valves on one connection this connection to the boiler shall have a cross-sectional area equal to or greater than the combined area of the two safety valves.

Safety valves having either the seat or disc of cast iron shall not be used.

The seats of all safety valves shall be inclined at an angle of forty-five (45) degrees to the center line of the spindle.

A certificate of inspection shall not be issued on a boiler used for heating purposes exclusively, permitting the boiler to be operated at a pressure in excess of fifteen (15) pounds, if the boiler is provided with a device (safety valve) in accordance with the provision contained in the Revised Laws, limiting the pressure carried to fifteen (15) pounds.

Each boiler shall have a steam gage connected to the steam space of the boiler by a syphon, or equivalent device, sufficiently large to fill the gage tube with water, and in such manner that the steam gage cannot be shut off from the boiler except by a cock with T end, placed directly on the pipe under the steam gage.

The dial of the steam gage shall be graduated to not less than one and one-half (1½) times the maximum pressure allowed on the boiler.

Each boiler shall be provided with a one-eighth (⅛) inch pipe size connection for attaching inspector's test gage when boiler is in service, so that the accuracy of the boiler steam gage can be ascertained, as required by section 3, chapter 465, Acts of 1907. (All such boilers shall also be inspected externally at least once each year to observe the pressure of steam carried and the general condition of each boiler, and to ascertain if the safety valves and the appliances for indicating the pressure of steam and level of water in the boiler are in proper working order. No person shall remove or tamper with any safety appliance prescribed by the board of boiler rules, and no person shall in any manner load the safety valve to a greater pressure than that allowed by the certificate of inspection.)

Each boiler shall have one fusible plug, as required by rules (section 3) on fusible plugs.

Each boiler shall have one water-glass, the bottom end of which shall be above the fusible plug and lowest safe water line.

Each boiler shall have two or more gage cocks, located within the range of the water-glass, when the maximum pressure allowed does not exceed twenty-five (25) pounds per square inch.

Each boiler shall have three or more gage cocks, located within the range of the water-glass, when the maximum pressure allowed exceeds twenty-five (25) pounds per square inch.

Each steam outlet from boiler shall be fitted with a stop valve.

When a stop valve is so located that water can accumulate, ample drains shall be provided.

Each boiler shall have a feed pipe fitted with check valve, and also a stop valve between the check valve and the boiler, the feed-water to discharge below the lowest safe water line. Means must be provided for feeding the boiler with water when the maximum pressure allowed is carried on the boiler.

Each boiler shall have a bottom blow-off pipe fitted with a stop valve or stop cock, and connected direct to the lowest water space of the boiler.

Where a damper regulator is used, the boiler pressure pipe shall be taken from the steam space of the boiler, and shall be fitted with a stop valve or stop cock.

Each boiler fitted with a Lamphrey boiler furnace mouth protector, or similar appendage, having valves on the pipes connecting same with the boiler, shall have these valves locked or sealed *open*, so that the locks or seals will require to be removed or broken to shut the valves.

Horse Power Rating.

A boiler having 1 square foot of grate surface shall be rated at three (3) horsepower when the safety valve is set to blow off at over twenty-five (25) pounds pressure per square inch.

A boiler having two (2) square feet of grate surface shall be rated at three (3) horsepower when the safety valve is set to blow off at twenty-five (25) pounds pressure per square inch or less.

Annual Internal Inspection.

The owner or user of a steam boiler which requires annual inspection, internally and externally, by the boiler inspection department or by an insurance company, as provided by section 1, chapter 465, Acts of 1907 (All steam boilers and their appurtenances, except boilers of railroad locomotives, motor road vehicles, boilers in private residences, boilers in public buildings and in apartment houses used solely for heating, and carrying pressures not exceeding fifteen (15) pounds per square inch, and having less than four (4) square feet of grate surface, boilers of not more than three (3) horsepower, boilers used for horticultural and agricultural purposes exclusively, and boilers under the jurisdiction of the United States, shall be thoroughly inspected internally and externally at intervals of not over one year, and shall not be operated at pressures in excess of the safe working pressure stated in the certificate of inspection hereinafter mentioned, which pressure is to be ascertained by rules established by the board of boiler rules, to be appointed as hereinafter provided; and shall be equipped with such appliances to insure safety of operation as shall be prescribed by said board. All such boilers installed after Jan. 1, 1908, shall be so inspected when installed. No certificate of inspection shall be granted on any boiler installed after May 1, 1908, which does not conform to the rules of construction formulated by the board of boiler rules), shall prepare the boiler for inspection by cooling it down (blanking off connections to adjacent boilers if necessary), removing all soot and ashes from tubes, heads, shell, furnace and combustion chamber; drawing off the water; removing the handhole and manhole plates; removing the grate bars from internally fired boilers, and removing the steam gage for testing.

If a boiler has not been properly cooled down, or otherwise prepared for inspection, the boiler inspector shall decline to inspect it, and he shall not issue a certificate of inspection until efficient inspection has been made.

In making the annual internal and external inspection the boiler inspector shall apply the hammer test to all internal and external parts of a boiler that are accessible.

All proper meaurements shall be taken by the boiler inspector, so that the maximum working pressure allowed on a boiler will conform to the rules relating to allowable pressures established by the board of boiler rules; such measurements to be taken and calculations made before a hydrostatic pressure test is applied to a boiler.

The steam gage of a boiler shall be tested and its readings compared with an accurate test gage, and if, in the judgment of the boiler inspector, the gage is not reliable he shall order it repaired or replaced.

Annual External Inspections.

The annual external inspection of a steam boiler should be made at or about six (6) months after the annual internal inspection, except in the case of a boiler that is in service a portion of the year only, in which case the annual external inspection shall be made during such period of service.

The boiler inspector shall attach an accurate test gage to a boiler to note the pressure shown by said test gage, and compare it with that shown by the boiler gage, ordering the boiler gage repaired or replaced if necessary.

The boiler inspector shall see that the water-glass, gage cocks, water-column connections and water blow-offs are free and clear; also that the safety valve raises freely from its seat.

Fire doors, tube doors and doors in settings shall be opened, to view as far as possible the fire surface, settings, tube ends, blow-off pipes and fusible plug, noting conditions and ordering changes or repairs if necessary.

Hydrostatic Pressure Tests.

When a boiler is tested by hydrostatic pressure, the maximum pressure applied shall not exceed one and one-half (1½) times the maximum working pressure allowed; except that twice the maximum working pressure allowed may be applied on boilers permitted to carry twenty-five (25) pounds pressure per square inch or less, or on pipe boilers.

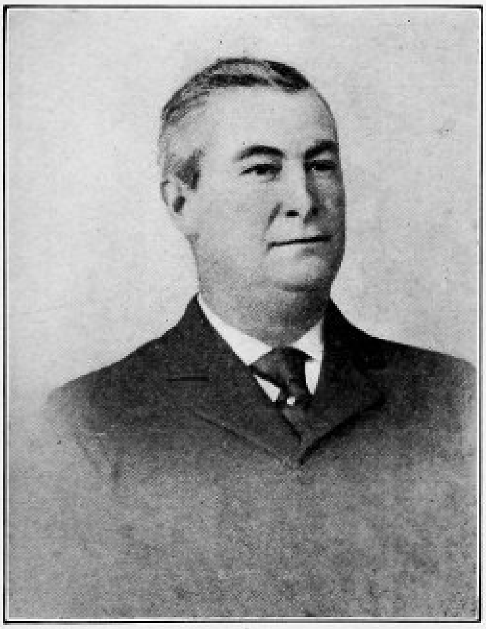
When making annual inspections on boilers constructed wholly of cast iron, or on pipe boilers, a hydrostatic pressure test of not less than one and one-half (1½) times and not more than twice the maximum working pressure allowed shall be applied.

The boiler inspector, after applying a hydrostatic pressure test, shall thoroughly examine every accessible part of the boiler, both internal and external.

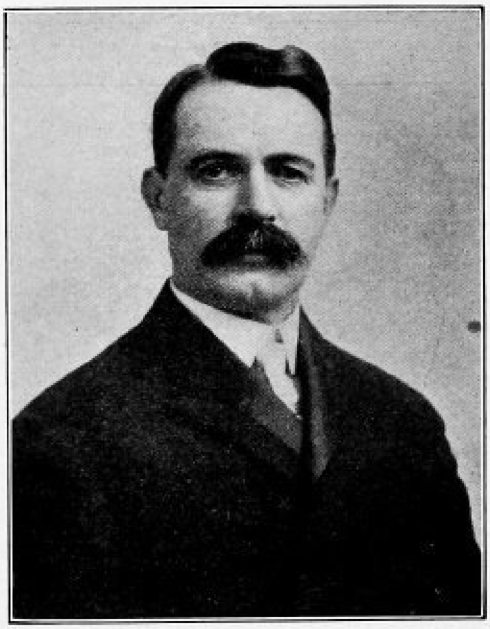
NINETEENTH ANNUAL CONVENTION OF THE AMERICAN BOILER MANUFACTURERS' ASSOCIATION

The nineteenth annual convention of the American Boiler Manufacturers' Association of the United States and Canada was held at the Piedmont Hotel, Atlanta, Ga., on Oct. 8, 9, 10, 1907. The convention was called to order by Mr. Frank Harrison, chairman of the local committee, who introduced Hon. Hoke Smith, Governor of Georgia. Governor Smith welcomed the convention in his usual felicitous manner.

Councilman Terrell was next introduced, and on behalf of Mayor Joyner, who was unable to be present, extended a cordial welcome to the visitors. He succeeded in making the manufacturers and their friends feel at home, and they heartily appreciated the welcome.



M. F. COLE, PRESIDENT.



J. D. FARASEY, SECRETARY.

Mr. W. H. S. Bateman, secretary of the associate members' organization and a representative of the Chicago Pneumatic Tool Company, responded on behalf of the American Boiler Manufacturers' Association, paying a high encomium to the South in general and Atlanta in particular.

Referring to the boiler manufacturers' industry, he pointed out that this is not what it was twenty years ago. It requires brains, science and skill to construct a boiler to meet the requirements not only of the United States Government but those conditions attendant upon the developments of the present date; especially is this true as applied to railroading. A greatly increased tonnage is now carried with correspondingly greater demand upon motive power.

At the conclusion of Mr. Bateman's address, Secretary J. D. Farasey, in behalf of Mr. D. J. Champion, of the Champion Rivet Company, Cleveland, Ohio, presented President Cole with a handsome gold mounted gavel, which was a model of the Champion rivet, upon which was engraved the following inscription: "To M. F. Cole, President American Boiler Manufacturers' Association, Atlanta, Ga., October, 1907, from an admiring friend."

President M. F. Cole then addressed the convention as follows:

"We have heard with great pleasure the addresses of the morning, and I join you in being delighted that only a small allotment of time remains for me.

"At our Pittsburg meeting I promised you a warm welcome when you should come to Atlanta, where Georgians and members from this belt wished to greet you without apology, and offer freely such hospitality as we can provide, and as Miranda says to Ferdinand in the Tempest, "Here's my hand with my heart in it.'

"I am proud of the honor at this time of being the president of this body, a convention of men who do not claim to be much on speeches but sublime when it comes to making noise. Our organization is one of the best and should be one of the largest in the country. The basic aims are correct in principle and most worthy as to ends sought. First, that we may meet on a common plane as friends and not as 'cut-throat' competitors, and, second, that we may manufacture boilers that are safe at lowest prices. In the former we have been absolutely successful and in the latter we are encouraged all the while by progress, and to-day members of the association are producing a type of boiler that has been on the market for more than a dozen years, and, so far as we have record, only one explosion has occurred, and that is accounted for by gross ignorance and criminal negligence. In fact, few people realize what has been accomplished outside the bone and sinew of the business. Within my own memory the changes are marked. When we had a small shop and the foreman was layer-out, the skilled man, a chief, we had a highly satisfactory Irishman named Patrick Gibbons, whose weakness, even in a dry town, was a sore trial, as it took a week to wind up a jag. Conscience stricken, he finally resigned at his own suggestion, and truly repentant, left sober, swearing eternal friendship and good fellowship, and also to send us a man who was both a capable and a sober boiler maker. After some four months he wrote from Memphis that he had located a man who had all of the skill and perfect habits, but as he was 6 feet underground, and could be sent only after refrigeration, he might not be available, and all sober boiler makers, so far as he knew, were in coffins, and he was not sure but of a right they ought to be. The machine riveter and flanging machine have greatly simplified regular work, and with a lessening of the trials, morals in workmen have improved in ours as well as in all other lines of business.

T. M. REES, FIRST VICE-PRESIDENT.

"We repeat, we welcome you most heartily, and bespeak for our nineteenth annual meeting of the American Boiler Manufacturers' Association of the United States and Canada one of pleasure and decided profit to us all."

TUESDAY AFTERNOON SESSION.

At the Tuesday afternoon session, President Cole appointed the following committees:

Auditing Committee—J. Don Smith, George N. Riley, S. A. Fortson.

Committee on Place of Next Meeting—W. A. Brunner, R. H. Bate, J. D. Farasey.

Committee on Resolutions—T. M. Rees, M. A. Ryan, J. J. Finnigan.

Nominating Committee—H. J. Hartley, George N. Riley, E. J. McDuffie.

Boiler Materials.

In presenting a verbal report for the committee on materials, Capt. Rees, in the absence of Chairman Meier, stated that it was very difficult to obtain proper boiler plate to pass the United States boiler inspection requirements, and that all of the mills in Pittsburg but one had refused to make this steel, and that one mill had successfully made it within the last few weeks. From all that Capt. Rees could learn he understood that the steel mills had been endeavoring to make boiler plate too cheaply, and in order to do this have been using inferior scrap. One mill in a recent heat, made entirely by the acid process instead of the basic process, and by using entirely new material, did not lose one sheet in the heats that were made, and filled all of the orders outstanding on their books. The speaker had an order in one mill for over six months, and believed that it is true that the mills are trying to furnish plate cheaper than the users of the plate desire, and have been trying to get out quantity instead of quality. He emphasized the fact that those who use boilers in his section of the country do not want a cheap or inferior quality of steel, but would be willing to pay a good price for steel equal to what was formerly furnished the trade if they could be allowed under the marine laws a steam pressure in accordance with the quality used. Capt. Rees stated that one mill in Pittsburg is now making under the acid process, steel that will meet all the requirements of the United States marine law, and that he had gotten a wagon-load of it the day before he left home. The speaker believed that if the mills that are not too badly rushed will put good material in the heats they will be able to get a boiler plate entirely satisfactory for the boiler manufacturers, and such as had not been had for many years.

DISCUSSION.

Mr. M. A. Ryan did not believe that the association for years to come could obtain a thorough repeal of the laws covering marine boiler inspection. Practically all of the work done by him is marine work, and he experiences a great deal of trouble in meeting the requirements of the present laws. The mills absolutely refuse to roll plate under the old specifications, and he has orders in for six months and no sign of plate yet. He was surprised to learn that any manufacturer would try to get an inferior grade of plate for the manufacture of marine or any other boilers, and as inferior steel will jeopardize life and property, the speaker did not believe that the manufacturers ought to supply such inferior steel even if a demand were made for it. Mr. Ryan commented unfavorably on the lack of qualifications on the part of some boiler inspectors, who were endeavoring to perform that duty which they were incapable of performing properly by reason of their ignorance of the subject. The local inspectors in his district were good, honest square fellows, and their chief was a very practical man, who had served his time in a machine shop, was an old engineer, and a man who would listen to reason; but it was simply an impossibility to manufacture boilers and comply with the existing marine boiler inspection laws, which are full of manifest contradictions and absurdities; and if a boiler could be made under such requirements it would not then pass inspection under the Hartford rules. He could not understand why regulations that are so absurd and detrimental should be permitted to remain in force. He did not understand why the mills could not furnish the quality of material demanded by boiler manufacturers if the boiler manufacturers are willing to pay for it.

President Cole invited Mr. W. L. Hirsch, of the American Steel & Wire Company, to address the convention on this subject.

Mr. Hirsch said that he had been a seller of boiler plate for twenty-five years, that he was located quite close to the mills and possessed some knowledge of the chemical and physical properties of steel. For twenty years his concern has made contracts with the leading railroads of the United States for fire-box and boiler steel, subject to the most rigid chemical and physical requirements in specifications of any steel that they produced, not excepting that for the United States Government. In earlier days they produced crucible steel, which was then the only steel in existence, and it is true that crucible steel is of superior quality, but the peculiarity of this steel is such that by reason of having to heat the metal in small pots it is impossible to make large plates, such as are demanded to-day, and in order to reduce the number of seams that are necessary for steamboat and locomotive boilers, we have progressed from that process, and in this development have gotten quantity at the expense of quality. It is now necessary to use the process that will produce plates of sufficient size to meet the present demands of boiler manufacturers and users. This is found in the acid process, which is a melting process. You cannot get out of the acid process any more than you put into it. The crucible is handled by a workman with tongs, and no larger pot can be used than the workman can handle and pour in this way. The resulting ingot is of comparatively small size, and it is impossible under this process to make a large plate, say 1¼ inches thick, 60 to 100 inches wide and of necessary length, because it would require too many pots, making it impossible to preserve a uniform heat, which unless secured would cause an un-uniform physical product.

On the contrary, however, by the acid process a good quality of steel is produced when good materials are used that is nearly equal to the steel produced by the crucible process. The speaker denied the truth of the statements made to the effect that steel manufacturers are employing an inferior quality of scrap. Scrap of a certain quantity is used alike in both the basic and acid processes. It is a fallacy to maintain that in the basic open-hearth process worn-out or burnt-up stuff, castings, tin cans, or anything that a goat cannot eat is used. The quality of boiler plate must be measured by its chemical and physical properties.

Under the Bessemer process are made rails, bars and all common steel products. Bessemer steel is made by blowing out impurities, and sometimes under the Bessemer process they will produce the chemical and physical qualities of boiler plate. However, no reputable concern would ever use Bessemer steel for boiler plate, because it would not give the proper results and it would be dangerous to human life to employ it.

The steel maker is not infallible, the speaker said, but endeavors to comply with the best specifications and to obtain the required chemical and physical results so long as they are within reasonable bounds. The American Steel & Wire Company has always sought for quality instead of quantity. A year ago last July the United States Government asked this company to comply with certain specifications for marine steel, which the company declined to do because the specifications were impracticable, not because the company could not produce high-quality steel; on the contrary, it has produced fire-box and boiler steel of high-class quality. The impracticable specifications referred to were possibly gotten up by men who did not understand the physical and chemical qualities of steel, and who required combined physical and chemical conditions which could not be practicably produced. An association representing all of the plate makers of the United States has frequently discussed all these conditions, and the speaker wrote to every plate maker in the United States requesting their views as to the new specifications of the Government. A majority of those addressed replied that they would decline to consider orders under such specifications. This company is anxious to supply not only the boiler makers but the United States Government with the product they require, but it cannot perform impossibilities. In this progressive age, when quantity is an urgent necessity, and when the prices have been forced down from $5.00 per cwt. to $1.70 per cwt., the same quality cannot be expected. The demand for common steel products is so extensive and insistent that we are compelled to give first attention to meeting this demand. The speaker was asked by an inspector of the Pittsburg district some time

MEMBERS OF THE AMERICAN BOILER MANUFACTURERS' ASSOCIATION AND THEIR GUESTS AT THE NINETEENTH ANNUAL CONVENTION IN ATLANTA, GA.
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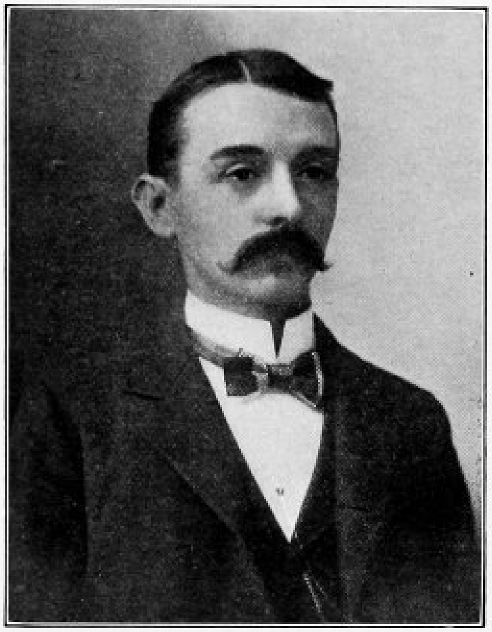
ago, "Hirsch, why don't you make marine steel plate?" and he answered, "Because we cannot produce it without losing money. The specifications are impracticable." Talk is one thing, but performance is another, and the specifications of the United States Government as they exist to-day are too drastic and impracticable. Surely a concern that has prided itself on quality for twenty-five years would not say that they could not produce the material unless it were impracticable.

The speaker contended that boiler plate that contains not to exceed .04 phosphorus and not to exceed .04 sulphur, with the tensile strength regulated entirely by carbon, is a good steel; and that when steel is produced which under test meets all of the specifications and is better than anything that was ever produced before, but is rejected because it shows a difference of not exceeding 1 percent between coupons cut longitudinally and those cut transversely, such rejection is unreasonable. Steel can be produced of a good quality, but we absolutely refuse to produce to fancy specifications gotten up by impracticable men. Steel showing 25 percent elongation, a stretch of ¼ inch in 1 inch or 2 inches in 8 inches, is certainly a good steel. Another man may demand 26 percent, another 27 percent, and so on up to 30 percent, at which point the steel manufacturers must stop. When a physician feels your pulse he knows whether it is normal or otherwise, but there are many things in steel production that are mysterious and uncertain, so that it is impossible to guarantee absolutely perfect and uniform results at all times. The manufacturer cannot guarantee you anything except to guarantee that he will comply with the physical and chemical specifications.



J. D. SMITH, SECOND VICE-PRESIDENT.

Continuing, the speaker said that he was absolutely familiar with the process of steel making, from the crucible to the basic, and also with the chemical and physical specifications necessary to produce boiler plate, fire-box and marine steel, and was confident that the manufacturers could not produce marine steel at 2 or 3 cents per pound and come out whole. Boiler manufacturers are right in enjoining upon the manufacturer that his steel must contain not more than a certain amount of phosphorus, a certain amount of sulphur and a certain amount of silicon; but the hardness and softness of steel is regulated entirely by the carbon. Tensile strength is not a question of quality but of hardness, or softness. Given the proper elongation, ductility and minimum tensile strength and you have ideal boiler steel. A tensile strength of 55,000 or 60,000 pounds with high elongation and ductility is better than 65,000 to 70,000 pounds tensile strength with less ductility and low elongation. When in use steel crystalizes and hardens, and the speaker would prefer to risk his life and the lives of others who have to do with boilers or come about them, with steel of the former rather than the latter kind. The speaker said that his company would not send out a plate that is not up to chemical and physical test, and this was not a bid for orders but only fair to state in justice to his company that it would not jeopardize life for profit. He therefore begged the boiler makers to bear kindly with the manufacturers and not to insist upon an absolute demand that was not practical, but rather to consult with the manufacturers and endeavor to meet the mutual requirements.

Replying to the last speaker, Capt. Rees said that he agreed with him that if the boiler manufacturer desired good steel he should pay for it. He had never experienced any trouble with crucible steel for fire-box and locomotive boiler use, and for the best article was willing to pay the best price; but steel made by the crucible process is now prohibited by the United States law. The speaker had protested against this prohibition, and is so on record. Since the absorption of most of the plate manufacturers throughout the country by what is called the United States Steel Corporation, and also the Crucible Steel Corporation, a great deal of competition in boiler plate has been cut out, but the speaker thought the day would come when new mills would arise to compete with these corporations, and undoubtedly this will lead to the production of better boiler plate. With this in view, and in order to throw open the doors of competition, crucible steel for boiler plate should not be prohibited by the United States Government. The speaker had submitted the physical proof before the department at Washington upon an occasion when a meeting of steamboat men and boiler manufacturers was called at Washington City. He took a test from a plate made in 1879 and placed it in comparison with a test from a plate made for a steamboat owned by the American Steel & Wire Company, and this comparison was submitted to Secretary Metcalfe at that time, proving that the plate made in 1879 was still good, although the other had deteriorated from the heat to which it had been subjected by use in the boiler so that it was utterly worthless.

The speaker said that neither the users or boiler manufacturers have approved the changes made in the marine law which had been brought about by the plate manufacturers in conjunction with the supervising inspectors, who made some changes in the test pieces without changing the rules to correspond therewith. For five years efforts have been made to secure a change in the rules to correspond with the change in the test pieces so as to allow the same steam pressure as formerly allowed. The speaker recently met a boiler inspector who showed him a test piece from a plate that he had recently tested, and had flattened it out at once with one blow of the hammer, and which on its face showed that it was a fine piece of steel and fully met the requirements. The inspector added that every piece pulled in that heat had passed satisfactorily the test required, and that this steel was fully equal to the boiler plate made in years past. The speaker said that he was fully satisfied that the steel from which this test piece was taken indicated that there would be no more trouble hereafter in getting the plate that boiler manufacturers desired. He had since learned that this plate of steel was a heat that the steel maker had received instructions to make by the acid process, using the very best material, and was informed that all that was needed was good material in order to make it properly by the acid process so as to fully meet all requirements. The speaker understood that it was not a question so much of cost with the manufacturers as it is a matter of detention and delays in getting material promptly.

Further answering the last speaker, Mr. Hirsch said that he would like to have the Boiler Manufacturers' Association consider the matter of increasing the thickness of their boiler plate and reducing the tensile strength in order to give them the same pressure, because it is easier to work a soft material of a thick gage than it is to work a hard plate of a thin gage. It seemed to the speaker that it would be better for the boiler manufacturer to employ a thicker plate of a softer and more ductile material rather than harder plate of a thinner gage that might give out more easily. The thinner a plate is made in the process of manufacture the harder it becomes. A plate 3/8 inch thick will show 25 percent elongation in 8 inches, while a 3/4 inch thickness will show 20 percent.

An invitation was received from the N. P. Pratt Laboratory to visit their modern and well equipped plant, after which an adjournment was taken until Wednesday morning.

WEDNESDAY MORNING SESSION.

The committee on place of next meeting reported in favor of Atlantic City, stating that a canvass of the members present had shown an almost unanimous sentiment in favor of this selection. After a full discussion, Atlantic City was selected as the place of meeting for the twentieth annual meeting. The discussion, which was participated in by Messrs. Meier, Riley, Farasey, Bate and Brunner, developed the feeling that there had been too much entertainment at past conventions, often on a very lavish scale, which was not objectionable, except for the fact that it gave to absent members an impression that nothing else but social pleasure occupied the attention of the members in convention. While this has not been the case it was thought best to omit all entertainment other than that of an individual character at the next convention, with the exception of the annual banquet, which would take place at the conclusion of the convention after all business had been attended to.

The report of the auditing committee, which was accepted, showed that the accounts of the secretary and treasurer were in proper shape.

The nominating committee reported as follows:

President—M. F. Cole, Newnan, Ga.

First Vice-President—T. M. Rees, Pittsburg, Pa.

Second Vice-President—J. Don Smith, Charleston, S. C.

Third Vice-President—W. A. Brunner, Phillipsburg, Pa.

Fourth Vice-President—H. D. MacKinnon, Bay City, Mich.

Fifth Vice-President—M. A. Ryan, J. J. Ryan Boiler Company, Duluth, Mich.

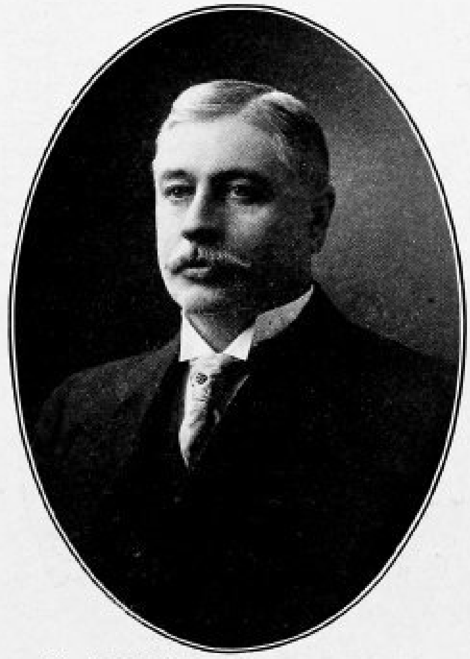
Secretary—J. D. Farasey, Cleveland, Ohio.

Treasurer—J. F. Wangler, St. Louis, Mo.

On motion of Capt. Meier the above-named were unanimously elected. The re-election of Mr. M. F. Cole as president was a deserved endorsement of his administration, and in accepting the honor he voiced his intention of doing energetic work during the coming year for the up-building of the association, increasing the membership and bringing out a greater attendance at the annual meeting.

Letters of regret were read from the following: Henry Golden & Sons Company, Philadelphia, Pa.; Grupe Drier & Boiler Company, Davenport, Iowa; E. Leonard & Sons, London, Can.; MacKinnon Boiler & Machine Company, Bay City, Mich.; S. Freeman & Sons Manufacturing Company, Racine, Wis.; Worth Bros. & Company, Coatesville, Pa.; Ashton Valve Company, Boston, Mass.; Hodge Boiler Works, Boston, Mass.; West Virginia Boiler & Machine Works, Mannington, W. Va.; Union Boiler & Manufacturing Company, Lebanon, Pa.; Erie City Iron Works, Erie, Pa.; Walsh's Holyoke Steam Boiler Works, Holyoke, Mass.; John H. Murphy Iron Works, New Orleans, La.; J. J. Duffy, Waterbury, Conn.; Frick Company, Waynesboro, Pa.; Atlantic Refining Company, Philadelphia, Pa.; D. Connelly Boiler Company, Cleveland, Ohio; Reading Iron Company, Reading, Pa.; West Brownsville Steam Boiler Works, West Brownsville, Pa.

A letter was read from M. Zier, secretary and manager of the Zier Boiler & Sheet Iron Company, New Albany, Ind., expressing his wish to become a member of the association and willingness to contribute to its support, also stating that the former firm of M. Zier & Company went into bankruptcy about five years ago on account of taking contracts in the State of Texas, and the writer stated that no doubt many other boiler manufacturers in the United States had lost thousands of dollars in the same manner. The writer suggested as important matters for discussion: First, the protection of manufacturers wishing to do business in the State of Texas; second, that boiler manufacturers should have protection on mill and



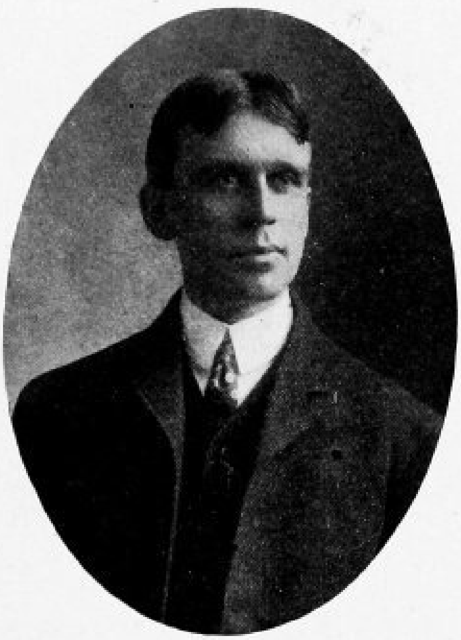
W. A. BRUNNER, THIRD VICE-PRESIDENT.

warehouse material. In reply to the latter suggestion, Col. Meier stated that if Mr. Zier had been a member of the A. B. M. A. he would have been aware of what had already been done in this direction, and called attention to resolutions passed at the Toronto meeting on the subject of selling to consumers.

Secretary Farasey said that many boiler manufacturers outside of the association were entirely ignorant of what had been accomplished by it. One such manufacturer had lately complained to him that nothing had been done in regard to marine boiler inspection laws, and in reply he had referred the gentleman to some thirty pages in last year's proceedings that show what the association had attempted to do in this direction, and while the greater amount of time, labor and money spent had not yet brought all of the results desired, yet the repeated agitation of the matter has undoubtedly accomplished much good.

Revision of Marine Laws.

Col. Meier, who was not present on the opening day of the convention, was asked to speak upon the subject of materials and also the revision of marine laws. Referring to the latter, he said that the boiler inspection service being now a department of the Bureau of Commerce and Labor, the proposed revision would have to come before Congress with the approval of that department, and it is now so busy with matters having to do with corporations generally that it is a bad time to agitate the matter further. He had been assured, however, by Mr. Herbert Knox Smith, Commissioner of Corporations, that while it would be impracticable to secure a wholesale revision of boiler inspection laws at this time, yet the department would cordially co-operate with the boiler manufacturers in any effort to amend or revise special sections of the law in order to meet modern commercial conditions. Col. Meier believes that the most practical way to secure what is desired in this direction will be in the manner indicated. At the time Secretary Shaw was at the head of the Treasury Department, the Boiler Inspection Department being then under his supervision, the A. B. M. A. committee on uniform boiler specifications secured his hearty endorsement of needed reforms proposed by them, and had at that time every prospect of success, except for the opposition of some very powerful interests of which at that time the speaker did not understand the source, but which he had since learned came from lake steamboat men, who were opposed to a general revision, because they knew what they already had, and were afraid that in getting something new they might get into worse trouble. At that time,



H. D. MACKINNON, FOURTH VICE-PRESIDENT.

also, the House committee was very favorable to the requests of the boiler manufacturers and received them very kindly, asking very intelligent questions, but still when the matter got into the House it failed on account of the opposition above referred to. Still, the speaker thought that by continuing to thrash matters out with the supervising boiler inspectors a good deal could be accomplished to relieve the odium of the present laws, and particularly to secure recognition of the different seam values. At present the law recognizes only the double-riveted lap seam, but one of the supervising inspectors has worked up some elaborate tables which he intends to propose, and which this association will then be called on to criticize. That is the only way to get things done, to go after it vigorously, energetically and persistently, one thing at a time, and to complete the thing you begin, although it may be very hard work. A general repeal of the law is impossible, and it would certainly be a waste of time and money to try to get it at this time, for the reasons stated.

In regard to the matter of materials, the speaker thought that the department had accomplished a great deal when you consider the condition of the trade some years ago. The A. B. M. A. specifications are used and approved, not only generally throughout this country, but requests are continually coming in from all over the civilized world. In regard to materials, the steel manufacturers objected to certain stringent specifications, and they went before the Board of Supervising Inspectors without the knowledge of this association, and secured the adoption of their own specifications with some modifications. Later, a conference was had with them by a committee from this association in New York to endeavor to get together, and the only essential point of difference was the matter of sulphur. The speaker said that he was able to obtain the steel with less sulphur in it by paying a better price, which he was willing to do; but the steel manufacturers said that they must have a little more latitude in regard to sulphur in supplying the general trade; however, the speaker thought there is no real antagonism between the two associations and that they could work together before the Board of Supervising Inspectors. The speaker did not agree with Mr. Bateman, who is no longer in the steel business, in the idea that we are getting at present better steel than ever before; this is not a fact. It is more difficult to get good steel now than a few years ago, owing to the tremendous wave of prosperity and the great demand upon the steel mills to turn out product which does not always result in the best quality unless you stand up for your rights and demand it. If you will insist upon tests every time you can get it, although it may be difficult, but the man who does not look out for himself in that respect will get something inferior on account of the rush of business in the mills.

The associate members and supply men, who had been conferred with touching the proposed omission of general entertainment features at the next annual convention, now reported, through Mr. J. T. Corbett, that the action taken by the parent organization was entirely satisfactory to the associate members, who would always be pleased to co-operate in any manner that they are requested to do to further the success of the conventions.

A letter of regret was read from Supervising Inspector General George Uhler, whose presence at the last convention was so highly appreciated.

A letter was read from the "grandfather of the association," Mr. James Lappan, conveying the sad intelligence of the serious illness of Mrs. Lappan, who was then in Philadelphia unable to be removed to her home in Pittsburg. Mr. Lappan sent warmest regards to association friends, and said that only duty to his life partner, which overtopped all other considerations, prevented his attendance. He counseled unity, and referred to the differences with unskilled labor and its unreasonable demands and vicious attitude towards employers in times of prosperity and on occasions when it was most necessary to fill contracts. If you are too submissive they will take advantage of the slightest weakness on your part, so that any indulgence is a waste of benevolence and commiseration.

Col. E. D. Meier, G. N. Riley and H. J. Hartley were appointed a committee to send a telegram of condolence to Mr. Lappan, and express the hope for a speedy recovery of Mrs. Lappan, and to express the regret of the convention that the "grandfather of the association" could not be in attendance. An adjournment was then taken until Thursday morning.

THURSDAY MORNING SESSION.

A telegram was read from Mr. Lappan in acknowledgment of that sent him by the association, and the associate members reported to the convention that their association had also forwarded a telegram of sympathy.

The special committee appointed to prepare resolutions in memory of Mr. Mathew Cole, submitted their report, and the same was adopted unanimously as follows:

In Memoriam.

MATHEW COLE.

Mathew Cole, who passed into the other life on Feb. 19, of this year, was born Jan. 25, 1823.

At the time of his death he was vice-president of the R. D. Cole Manufacturing Company, of Newnan, Ga., and the father of M. F. Cole, the latter being a member of the same firm and also president of the American Boiler Manufacturers' Association. Although being slightly past his 84th year at the time of his demise, he was in the full possession of all his faculties, and so robust and vigorous that he could have mounted a horse with more ease than any one of his five sons, all of whom survive him. Mathew Cole was a man of strictly temperate and regular habits in all respects. He lived a life of modest and unassuming usefulness; setting before his sons, whom he gathered around him in his business, assigning to each a position suited to his abilities, an example which was more than precept and which was no inconsiderable asset of this successful firm. The business was originally managed by himself and his brother, R. D. Cole; and of these two brothers it may be said that during fifty-three years of business life together they never had a single word of disagreement. The business so successfully founded by him is now carried on by the second generation, the five sons of Mathew Cole, who, following in the footsteps of their father and uncle agree perfectly with each other in all things. Of Mathew Cole it may be said, as Thackeray says of one of his characters, "He could look the world honestly in the face with an equal manly sympathy for the great and the small."

Mathew Cole was beloved by all in the community where he was reared and known. He never told of the many acts of kindly charity which he performed; obeying the Scriptural injunction, "Let not thy left-hand know what thy right-hand doeth."

Governor Terrell, of Georgia, in a letter written by him upon the occasion of the fiftieth anniversary of the founding of the R. D. Cole Manufacturing Company, paid the following tribute to Mathew Cole and his brother R. D. Cole:

"Rich, indeed, are the venerable brothers who have labored side by side so long in love and gentleness; rich in the contemplation of their well-spent lives; rich in the knowledge that they have builded so well for others; rich in the radiance of industry and noble Christian living which they have shed all around them; and richer are their neighbors, and richer is Georgia for the example of their lives. It seems to me that nowhere has there been a finer example of simple Christian living, combined with superb business judgment and all that is constructive in industry."

Respectfully submitted,
T. M. REES,
M. A. RYAN,
J. J. FINNIGAN,
Committee.

Mr. John J. Finnigan, of John J. Finnigan & Company, Atlanta, Ga., was elected to active membership and was introduced by President Cole. Mr. Cole stated that he had known Mr. Finnigan for many years and considered him one of the best posted men in his line. Mr. Finnigan acknowledged the courtesy, and promised his unqualified support to the association.

The greater part of Thursday morning was taken up with an executive session, from which the convention arose for a sufficient length of time to receive the members of the supply men's association, who filed in with great dignity and paid their respects, and promised their hearty co-operation to make the twentieth annual convention at Atlantic City the best ever.

It is learned that during the executive session attention was given to the labor situation, and the necessity for united effort in a practical way just as the labor men do themselves. No enmity was expressed to labor organizations as such, but a decided stand, in pursuance of the suggestion of Mr. Lappan, was urged as against the unjust encroachments of labor agitators and others on the rights of manufacturers.

Another matter that was quite freely discussed was the proper attitude which private inspectors and also consulting engineers should occupy in their relation to contractors. It frequently happens that such inspectors or engineers take practically the position of an attorney for the purchaser, when they should rather stand impartially between the two parties and content themselves with seeing that the work contracted for is fairly done, and not attempt to get more out of a manufacturer than he has agreed to do.

An example was cited by a member of the association who had put in an engine foundation and located it according to the drawings. Afterward the consulting engineer concluded it would do better in a different location, a matter of several feet away, and his first demand was that the contractor should change the location to this point without extra pay. That was resisted. Finally, they agreed on that. Then it turned out that at the location he wanted it moved to there was a well 4 feet in diameter and 10 feet deep, and the consulting engineer actually had the face to insist that the contractor should fill up that well. It was claimed in the discussion that such inspectors should have good horse sense and decency, and while standing up for the rights of their employer, they should not assist him in an attempt to cheat the contractor.

THURSDAY AFTERNOON SESSION.

At the Thursday afternoon session, before again taking up their executive session, the convention adopted by unanimous vote the following resolution of thanks:

Resolution of Thanks Offered by Secretary Farasey and Unanimously Adopted by the American Boiler Manufacturers' Association in Convention Assembled At Atlanta, Ga., Oct. 10, 1907.

Whereas, At our nineteenth annual convention, held in the city of Atlanta, Ga., the American Boiler Manufacturers' Association, its active and associate members and guests, have enjoyed to the fullest the courtesies showered upon us here, and have highly appreciated the opportunity of visiting this thriving and enterprising city, which may be termed the "Chicago of the South"; and,

Whereas, It is fitting that some formal expression be given collectively of the gratitude which we all individually feel toward our entertainers; therefore,

Be it Resolved, That the American Boiler Manufacturers' Association in convention assembled tender sincere and heartfelt thanks by rising vote to the following named:

To Hon Hoke Smith, Governor of Georgia, who so cordially welcomed us to this magnificent type of the progressive cities of the South; and to his estimable lady who received us at the executive mansion.

To Hon. W. M. Terrell, the special representative of his honor, Mayor W. R. Joyner.

To the R. D. Cole Manufacturing Company, whose president is also our president, and whose hospitality we enjoyed at the barbecue.

To the ladies' reception committee, Mrs. Adam Jones, chairman, who with her sisters on the committee ministered to the pleasure and comfort of our ladies; and to Mrs. William L. Peel, who especially entertained some of our ladies.

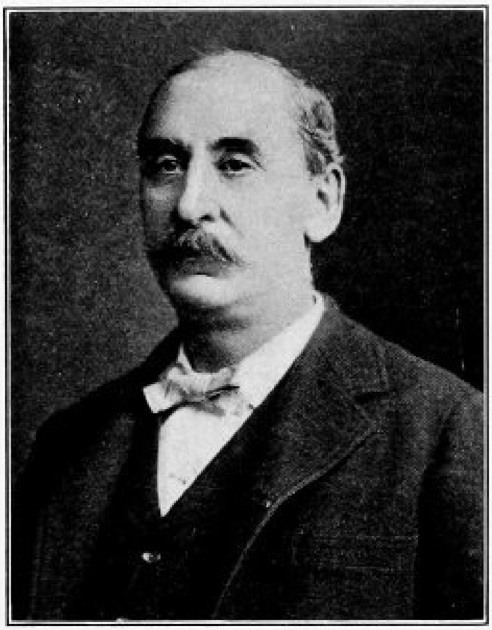
To Mr. Frank Harrison, chairman, and his able assistants on the local committee of arrangements, who have been untiring in their attentions and courtesies since our first arrival here.

To the associate members and supply men's organization, and especially Acting President John T. Corbett and Secretary W. H. S. Bateman, all of whom have contributed to our pleasure.

To the witty and entertaining speakers at our banquet; to the management and attaches of the Piedmont Hotel, who have catered to our creature comforts, and lastly, to the daily and technical press for their comprehensive reports of our meeting.

Is the Sudden Stopping of High-Pressure Marine Engines Detrimental to the Boiler?

As a contribution to the discussion of this question, Mr. J. D. Smith requested the secretary to read a clipping from the September issue of the *American Marine Engineer*, in which was considered the question of whether too little water or too much oil was the cause of a collapsed furnace, and the writer stated that in his opinion the sudden stoppage of an engine, especially a high-pressure one, has brought more crowns down than low water or excessive use of cylinder oil. He was selected as one of two engineers to stand watch in the boiler room of a Pennsylvania Railroad ferryboat for the New York



J. F. WANGLER, TREASURER.

Twenty-third street ferry while the boat was being conveyed to New York from a Philadelphia shipyard. While in charge of some of the fitting up of the boilers he had placed gaskets on all manhole plates and had objected to using the common low-pressure gaskets kept in stock by the firm, but the foreman overruled his objections, and they were used. There were four Thornycroft boilers of large type, carrying 180 pounds steam pressure, which was cut down to 150 pounds at the engine by a reducing valve. Each boiler had three cylindrical-shaped legs, having a manhole in each leg, in the fire-room end of the boiler.

On the trip the nuts on the dogs of the manhole plates were repeatedly screwed up (the pressure being too great for the type of gasket used) until the rubber was actually forced out, and practically the bare canvas was all that remained. The plates were kept from leaking on the whole trip, but no one above gave any information of being close to the dock in Hoboken, and when a sudden stop was made, the instant the steam was shut off from the engines the water and steam gushed out of the manhole plates in the legs of all four boilers; and the writer frankly confesses that never in his whole career as an engineer has his heart and his stomach been so close together. His partner and himself, both being in the fire-room at the time, gingerly tackled all twelve plates and screwed them up, stopping the leaks. This experience proved that a sudden stoppage of the flow of steam with heavy fires in operation and safety valves unable to cope with the surplus steam will cause such a sudden shock that the crowns must suffer.

Several years ago one of the ships of the company the writer is now serving with came into port with one of her crowns buckled, not badly, but plainly enough to be seen by any one. The ship had two boilers and two furnaces in each boiler, and only one furnace had buckled. When a crown comes down, the first charge against the engineer is too much oil; and so the boiler maker and the assistant engineer stood by to see that the crown was not touched, after the boiler was blown out and opened up, until headquarters had seen for itself the condition of the boiler. Everything was found in first-class shape; not a trace of oil could be found, nor was there any known weakness of the furnace tubes.

In the investigation that followed it was found that the captain made a practice of stopping (without any warning to the engineers) the ship at sea to heave the deep sea lead. Less than 2 minutes after a sounding the furnace came down, and the shock, and nothing but the shock of sudden stopping, in my opinion, brought it down. The chief was exonerated and the captain was warned against a repetition of such practice.

Mr. Rurke thought that the sudden stopping of a high-pressure marine or other engine, if the same was properly constructed and working at normal pressure, should not be detrimental to the boiler, and gave as a reason that he had seen a cotton press at Savannah, Ga., in operation, and as the bales were introduced and again withdrawn and the pressure relieved, the needle would fluctuate 10 or 15 pounds, and there were no bad results during the three or four years he had seen it in operation.

Capt. Rees stated that he had built the boilers for the compresses in question, the batteries previously in use having exploded on account of this excessive variation of pressure, and because the heads had not been properly stayed. The fall was somewhere about 20 or 25 pounds in pressure at every revolution of the cylinder.

Mr. Kehoe thought that such sudden stopping and starting would injure a boiler, and that the boiler should be built especially to withstand the extra pressure.

Mr. Finnigan said that he had stood on the side of a compress boiler at the Atlantic Compress Company, and seen the boiler breathe or pulsate with the variation in pressure. They were carrying from 120 pounds to 150 pounds pressure. He thought it detrimental to the boiler.

Mr. Cole agreed with the last speaker.

Col. Meier thought that such use was about the severest test that could be put on a boiler.

Mr. Rees said that he put drums on, and instead of leaving a solitary opening he put on a double drum with the openings quite large, so that there would not be a sudden draw in one part of the boiler. He thought that unless the boiler was built especially to stand such strain it would in time fracture.

Mr. Ryan, of Duluth, thought that with a boiler built for a certain pressure the sudden opening of the throttle valve ought not to make any difference. A boiler built according to standard specifications for 150 pounds pressure ought to stand at least 1,000 pounds bursting pressure, and he could not understand why such a boiler, properly built, would vibrate as represented. He had seen pulsation in a battery of boilers running a big Corliss engine of, say, ½ inch to ¾ inch, with steam drums on them; but he had no faith in steam drums, and thought a good dry-pipe with a large opening was as good as a steam drum. He considered the latter nothing but a condenser, and if a condenser is wanted, let it be put on the engine.

Col. Meier thought that the wear and tear on a boiler of a cotton press is much more severe than in the case of a marine or any other engine. He asked for the difference between cutting off at every stroke and cutting off once for all with the throttle valve. The boiler has to stand the same pressure in either case. It can hardly be said to be detrimental to the boiler, because you cut off just as suddenly with the regular cut-off mechanism as with the throttle.

Mr. Ryan stated that a 72-inch boiler properly braced will move from 1/8 inch to 3/16 inch, and this, so far as he knew, is not detrimental with a regular standard high-pressure or slide engine, if the boiler is properly constructed and only carrying its rated capacity of steam. If built for 100 pounds pressure, and carrying 100 pounds, that would be a different proposition.

Mr. Brunner thought it depended upon how fast the boiler will evaporate water and make steam. The safety valve ought to take care of the increased pressure, and he did not think it would be detrimental.

Mr. Ryan thought that the greatest detriment to marine boilers in lake practice is the fact that the engineers do not have sufficient time to take care of the boilers when they are in port. They come into the ore docks, blow off, pour cold water in the boilers, and in 5 or 6 hours are going out with steam up. He thought, however, that the safety valve ought to take care of the trouble referred to in the question.

Mr. Hartley mentioned the fact that the majority of violent explosions that have taken place in marine boilers have been at the starting of the boilers, not the stopping. A marine engine takes steam with a gulp that relieves the pressure that has been standing on the boiler. Probably the boiler plates have become overheated, decomposition of steam takes place, and as soon as the pressure is relieved and the globules have been released, the over-heated plates cause a greater volume of steam to be generated than the safety valves can take care of, and consequently, if the boiler is weak an explosion takes place. The same thing applies to locomotive boilers. Locomotives are liable to be suddenly stopped, and the safety valves must take care of the pressure. Mr. Hartley could not understand the great pulsation of the boilers mentioned. If they were cylindrical boilers, perfectly round, how could they pulsate, as the pressure is equal on all sides?

Concluding his remarks, Mr. Hartley paid his respects to the steam dome on boilers, which he condemned strongly. Others present agreed with him in this matter.

The Boiler Inspector.

The next question was. "Is the ordinary boiler inspector of the insurance companies and the Government a hindrance or an aid to the boiler manufacturers?"

In discussing this point, Col. Meier said that the question could not be answered categorically, it depends upon the man. If well posted and honest, he is a help; otherwise, a decided hindrance. In this there was general agreement, Mr. Bate stating that in his section of the country general reliance was paid to the inspector's advice in the matter of specifications, etc., and he did not know how they would get along without the inspector.

Spacing of Flues.

The third question suggested by Mr. J. D. Smith was as follows: "Can any of the members give from experience or practical testing the best spacing of tubes in high-pressure boilers?"

In answer to the above, Mr. Richard H. Bate, of William T. Bate & Son, Conshohocken, Pa., read the report of a special committee on this subject which was made to the A. B. M. A. in 1889, and appeared in their printed proceedings of that year, and is as true now as it was then, viz.:

The question of tube spacing is largely dependent on the quality of water to be used, and also on the circulation of the water in the boiler. The generally received opinion of water circulation is that there are two currents at work in the boiler. Both have their rise at the bottom, just over the fire. One is a fore and aft circulation; the other an up and down current. The fore and aft current rises among the tubes carrying the water from the lower front to upper back end. There it falls and sweeps the bottom to the front again. The up and down current rises among the side tubes and falls among the center tubes, the center being colder than the sides. The spacing must be arranged to give as free play to these currents as possible, so that when steam is formed on a plate it may be immediately swept off and taken to the steam space. It appears to be necessary to have a large space at the bottom of the boiler, so that a sufficient body of water may be maintained there to prevent burning. There should be a good space between the shell and tubes, and a center space should be allowed between the tubes for a downward current.

The distance of the tubes from each other should be dependent on the quality of water used, but must be enough to allow a free circulation. Our practice is to allow a space between shell and tubes of one-eighteenth of the diameter of the boiler. This gives 3 inches of space in a 54-inch boiler and 4 inches in a 72-inch boiler.

The center space should be one-twelfth of the diameter of the boiler, giving 5 inches in a 60-inch and 6 inches in a 72-inch boiler. This rule is independent of the size of the tubes.

Each tube should be one-third of a diameter from every adjoining tube, both horizontally and vertically, but no tube of any size should be nearer than 1 inch to any other. One good reason for this minimum is that less distance will not give sufficient strength to the metal between holes to resist the stretch of the expander in resetting tubes.

There should generally be a manhole below the tubes, especially when the water is bad, to facilitate cleaning; also to make sure that there is a sufficient body of water below the tubes. In small boilers use a small manhole or a very large handhole.

The tubes should not be placed higher than three-fifths of the diameter from the bottom of shell, except where a dome is used, when they may be carried one row higher. One method of arriving at the proper number of tubes in a head is to make their inside area a certain percentage of the area of the head; 16 to 18 percent of the area of the head seems to give good results. The ends of tubes should be beaded to aid the tubes in staying the heads.

Cold Water Testing.

The fourth question was, "Is the testing of boilers with cold water injurious to same?"

Col. Meier in reply said that that depends upon several circumstances. If you were testing a boiler at Duluth, where the temperature was 40 below zero, I would advise warming the water a little; but if testing in Georgia in the summertime at 104 in the shade, you would not need to warm the water. Any thing can be made very injurious if carried to extremes. We recommend in the standard specifications that were adopted by this association that the hydrostatic test shall never on boilers built strictly to the specifications exceed working pressure by more than one-third of itself, and this excess limited to 100 pounds per square inch. The water used for testing to have a temperature of at least 125 degrees F. The speaker was asked whether as a practical boiler builder, building for his own use, he would test with cold water, and replied that he believed he would.

Mr. Brunner was in favor of cold water but not above the pressure to be carried.

Before the adjournment of the convention, President-Elect Cole acknowledged the compliment paid him in his re-election as president, and congratulated the members on the fact that there was evidently more ginger being displayed and every prospect of a healthy growth of new timber during the coming year. There was a general feeling that the convention to be held next year at Atlantic City would bring out the largest attendance for many years, and meantime vigorous campaign work is to be done.

The convention then adjourned sine die, to meet on dates to be hereafter fixed, at Atlantic City, 1908.

The entertainment features of the convention included many special attentions to the ladies, such as trolley parties, tours through shopping districts, theater party for all members, a trip to Marietta, etc. On Wednesday afternoon, at the Ponce de Leon Cue grounds, a barbecue was tendered to the convention by the R. D. Cole Manufacturing Company, and was to the Northern visitors especially a very unique form of entertainment. It was followed by dancing and other recreations at the pavilion. The same evening a delightful informal reception was held at the Piedmont, and on Thursday evening the annual banquet was held at the hotel.

Among those present at the convention were the following:

Thos. Aldcorn, Chicago Pneumatic Tool Company, New York; W. A. Brunner, Tippett & Wood, Phillipsburg, N. J.; Mrs. W. A. Brunner, Phillipsburg, N. J.; W. H. S. Bateman, Chicago Pneumatic Tool Company, Philadelphia, Pa.; E. R. Blagden, National Tube Company, St. Louis, Mo.; H. S. Bartlett, Ingersoll-Rand Company, Birmingham, Ala.; James E. Brady, The J. H. McGowan Company, Cincinnati, Ohio; Richard H. Bate, Wm. T. Bate & Son, Conshohocken, Pa.; J. T. Corbett, Jos. T. Ryerson & Son, Chicago, Ill.; L. O. Cameron, Pressed Steel Car Company, Atlanta, Ga.; Mrs. L. O. Cameron, Atlanta, Ga.; Mrs. E. M. Cole, Atlanta, Ga.; E. M. Cole, R. D. Cole Manufacturing Company, Atlanta, Ga.; Miss Sue Crawford, Philadelphia, Pa.; Miss A. B. Chute, Youngstown, Ohio; Col. M. F. Cole, R. D. Cole Manufacturing Company, Newnan, Ga.; Mrs. M. F. Cole, Newnan, Ga.; Miss Christine Cole, Newnan, Ga.; Miss Ruth Cole, Newnan, Ga.; D. P. Corwin, Atlanta, Ga.; Mrs. D. P. Corwin, Atlanta, Ga.; Judge A. E. Calhoun and wife, Atlanta, Ga.; D. J. Champion and wife, Champion Rivet Company, Cleveland, Ohio; T. B. Davies, Carnegie Steel Company, Atlanta, Ga.; Mrs. T. B. Davies, Atlanta, Ga.; F. A. Dilworth, Carnegie Steel Company, Atlanta, Ga.; C. N. Dannals, Jones & Laughlin Steel Company, Atlanta, Ga.; R. P. Decker, Cleveland Pneumatic Tool Company, Atlanta, Ga.; H. F. Deverell and wife, The Otis Steel Company, Ltd., Cleveland, Ohio; W. O. Duntley and wife, Chicago Pneumatic Tool Company, Chicago, Ill.; J. F. Farasey, H. Teachout Boiler Works, Cleveland, Ohio; Mrs. J. D. Farasey, Cleveland, Ohio; C. H. Fresher, Philip Carey Manufacturing Company, Atlanta, Ga.; P. W. Gorman, Philip Carey Manufacturing Company, Birmingham, Ala.; J. J. Finnigan, J. J. Finnigan & Company, Atlanta, Ga.; H. C. Finley, Scully Steel & Iron Company, Chicago, Ill.; William M. Francis, Hartford Steam Boiler Inspection & Insurance Company, Atlanta, Ga.; Mrs. William M. Francis, Atlanta, Ga.; Hon. John T. Graves and wife, Atlanta, Ga.; Robert S. Groves, Worth Bros. Company, Coatesville, Pa.; Miss Mattie Gregory, Atlanta, Ga.; John F. Glenn, Wilkes Bros. Company (Saginaw), Birmingham, Ala.; J. H. Grubb, J. E. Lonergan & Company, Philadelphia, Pa.; Col. H. A. Hall and wife, Newnan, Ga.; Miss Julia Hunter, Atlanta, Ga.; A. J. Hamilton, National Tube Company, New York, N. Y.; Miss Dorothy Harrison, Atlanta, Ga.; Frank Harrison, Atlanta, Ga.; H. J. Hartley, William Cramp & Sons, Philadelphia, Pa.; H. B. Hare, The Otis Steel Company, Ltd., Cleveland, Ohio; Mrs. H. B. Hare, Cleveland, Ohio; Wm. L. Hirsch, American Steel & Wire Company, Pittsburg, Pa.; Mrs. E. H. Hunter, Atlanta, Ga.; W. H. Hill, Harper & Walker, Pittsburg, Pa.; Col. Sam. D. Jones and wife, Atlanta, Ga.; A. W. Jones and wife, International Steam Pump Company, Atlanta, Ga.; Mrs. C. P. King, Atlanta, Ga.; C. P. King, American I. & S. Manufacturing Company, Atlanta, Ga.; E. Kingley, Philip Carey Manufacturing Company, Charlotte, N. C.; Paul M. King, Worth Bros. Company, Coatesville, Pa.; J. W. Longwell, Carnegie Steel Company, Atlanta, Ga.; Mrs. J. W. Longwell, Atlanta, Ga.; J. P. Lyons, Carnegie Steel Company, Atlanta, Ga.; A. C. Langston, Jos. T. Ryerson & Son, Chicago, Ill.; D. M. Montgomery, Monongahela Tube Company, New Orleans, La.; Thos. McNeil, Jr., McNeil Bros. Company, Pittsburg, Pa.; S. J. McGarry, J. J. Finnigan & Company, Atlanta, Ga.; Mrs. S. J. McGarry, Atlanta, Ga.; W. H. McAlpin, J. J. Finnigan & Company, Atlanta, Ga.; Mrs. W. H. McAlpin, Atlanta, Ga.; John McGarry, J. J. Finnigan & Company, Atlanta, Ga.; James McGarry, J. J. Finnigan & Company, Atlanta, Ga.; V. A. Moore, Upson Nut Company, Atlanta, Ga.; Mrs. V. A. Moore, Atlanta, Ga.; A. S. McEldrowney, Scully Steel & Iron Company, Chicago, Ill.; E. McDuffie, Marion Iron Works, Marion, S. C.; James McKenzie, Jameson, McKenzie & Evans, Baltimore, Md.; Miss Mary Moore, Atlanta, Ga.; W. L. Peel, Atlanta, Ga.; Mrs. W. L. Peel, Atlanta, Ga.; Charles Parsons, Independent Pneumatic Tool Company, Chicago, Ill.; Geo. N. Riley, National Tube Company, Pittsburg, Pa.; Mrs. Geo. N. Riley, Pittsburg, Pa.; Capt. T. M. Rees, James Rees & Sons Company, Pittsburg, Pa.; Mrs. T. M. Rees, Pittsburg, Pa.; J. T. Rose, American Bridge Company, Atlanta, Ga.; J. H. Schoenley, Phœnix Iron Company, Baltimore, Md.; Mrs. J. H. Schoenley, Baltimore, Md.; J. Don Smith, Valk & Murdock Company, Charleston, S. C.; John J. Ryan, J. J. Ryan Boiler Company, Duluth, Minn.; Hon Hoke Smith and wife, Governor of Georgia, Atlanta, Ga.; George Slate, THE BOILER MAKER, New York, N. Y.; C. T. Smith, Chicago Pneumatic Tool Company, Cleveland, Ohio; Mrs. C. T. Smith, Cleveland, Ohio; J. F. Thrash, J. F. Thrash, Dallas, Tex.; J. M. Van Harlinger, Manufacturers' Agent, Atlanta, Ga.; Mrs. J. M. Van Harlinger, Atlanta, Ga.; Miss Louise Van Harlinger, Atlanta, Ga.; Miss E. Woodruff, Philadelphia, Pa.; Jos. F. Wangler, Jos. F. Wangler Boiler Works, St. Louis, Mo.; Mrs. Mary Zippler, Coatesville, Pa.; R. S. Armstrong, R. S. Armstrong & Bro., Atlanta, Ga.; Mrs. R. S. Armstrong, Atlanta, Ga.; J. P. Armstrong, R. S. Armstrong & Bro., Atlanta, Ga.; Douglas A. Brown, official reporter A. B. M. A., Cincinnati, Ohio; George Grooby, Atlanta, Ga.; Wm. Kehoe, Wm. Kehoe & Sons, Savannah, Ga.; D. M. Montgomery, Monongahela Tube Company, New Orleans, La.; John Rourke, John Rourke & Sons, Savannah, Ga.; Horace Parker, American Steam Gauge & Valve Company, Atlanta, Ga.; Mrs. Horace Parker, Atlanta, Ga.; J. Wiley Pope, Atlanta Chamber of Commerce, Atlanta, Ga.; John W. Stiles, Keasby & Mattison Company, Atlanta, Ga.; Geo. Dole Wadley, A., B. & A. Ry., Atlanta, Ga.; Mrs. Geo. Dole Wadley, Atlanta, Ga.; G. T. Schnatz, Lukens Iron & Steel Company, Philadelphia, Pa.; Hugh Tudor, Tudor Boiler Manufacturing Company, Cincinnati, Ohio; Col. E. D. Meier, president Heine Safety Boiler Company, New York, N. Y.; J. G. Belding, Lombard Iron Works & Supply Company, Augusta, Ga.; M. G. Weidner, Walsh & Weidner Boiler Company, Chattanooga, Tenn.; Charles Kroeschell, Kroeschell Bros. Company, Chicago, Ill.; Mrs. A. M. Werner, Atlanta, Ga.; H. A. Flagg, Shelby Steel Tube Company, New York, N. Y.; J. R. Bailey, Tyler Tube & Pipe Company, Philadelphia, Pa.; Mrs. J. R. Bailey, Philadelphia, Pa.; J. E. Brantley, L. & N. R. R., Atlanta, Ga.; J. A. Davis, R. C. Hoffman & Company, Baltimore, Md.; John S. Schofield, J. S. Schofield, Sons Company, Macon, Ga.; J. E. Minetree, Shelby Steel Tube Company, New York, N. Y.; R. N. Cole, R. D. Cole Manufacturing Company, Newnan, Ga.; Mrs. R. N. Cole, Newnan, Ga.; D. B. Prosser, American Iron & Steel Manufacturing Company, Atlanta, Ga.; S. A. Fortson, Lombard Iron Works & Supply Company, Augusta, Ga.; Jos. Durfey, Atlanta Steel Company, Atlanta, Ga.; A. W. Taylor, Atlanta Steel Company, Atlanta, Ga.;

J. Stewart Cole, R. D. Cole Manufacturing Company, Newnan, Ga.; W. H. Hudson, Atlanta Locomotive Works, Atlanta, Ga.

Proceedings of the Associate Members.

The Associate Members and Supply Men's organization held several well attended business sessions during the dates of the A. B. M. A. meeting, and adopted a constitution and by-laws for their future government. They re-elected the following officers:

President—W. O. Duntley, Chicago Pneumatic Tool Company, Chicago, Ill.

Vice-President—J. T. Corbett, J. T. Ryerson & Son, Chicago, Ill.

Secretary—W. H. S. Bateman, Chicago Pneumatic Tool Company, Philadelphia, Pa.

Treasurer—H. B. Hare, Otis Steel Company, Cleveland, Ohio.

Their executive committee for the coming year will be appointed by their president later. Definite rules regarding future entertainment features generally were adopted. Local committees are to be abandoned so far as taking care of entertainment, and this work will be looked after by members of the executive committee of the supply men's organization as designated by its president.

In reply to the message of sympathy which the supply men's organization forwarded to Capt. James Lappan they received from him a cordial response. Resolutions of thanks were adopted also by them to the R. D. Cole Manufacturing Company, and a committee was appointed to confer with the parent organization as to dates of next meeting.

The Trend of Modern Locomotive Boiler Design.*

BY T. HURRY RICHES.

As the result of the ever-increasing demands made upon the locomotive, and owing to the limited dimensions within which enlargements may be made, the design of the boiler has been brought very prominently under consideration. With the increased steam pressure used to-day, it follows that a much larger fire-box and much greater heating surface are imperative. In connection therewith numbers of devices and experiments have been tried with more or less success; I do not, however, propose here to criticise the work of any designer, but to merely mention the fact that these devices have been brought into existence.

First, there is the cone boiler, with the large fire-box, having a large space round the box and above the crown so as to give plenty of steam-space, the barrel gradually tapering down to a smaller dimension at the leading end. This practice has been growing now for many years.

Next there is the Belpaire fire-box which has been introduced into the British locomotive now for some years with more or less success, although doubtless this class of boiler requires greater care in construction and somewhat greater care in management and repairs, to maintain and work it as economically and for as long a time as was the case with the older class of boiler.

Next comes the plan of Mr. Drummond, where he uses cross tubes in the fire-box, and where I understand he has succeeded in getting a considerably improved evaporative duty in consequence. It must not be forgotten, however, that many years ago some of our predecessors used water mid-feathers and transverse tubes. It is true that these were of large diameter, but whether from the lack of experience or from the lower quality of material that had to be used, all those old schemes have passed away as being too costly to maintain and too difficult with which to keep stock running constantly. In these days of high pressures, not only in the sense of steam pressure but also of heavy and continuous work by the locomotive, it is essential that the boiler should be well and as far as possible simply made, so that its maintenance and treatment may be easy and economical, because the larger firegrates and heating surfaces, together with the more rapid generation of steam at much higher pressure, have put upon the modern locomotive boiler much extra stress compared with the older type.

* Extract from presidential address at the spring meeting (1907) of the Institution of Mechanical Engineers.

Removing Scaled Boiler Tubes.

A correspondent to the *Engineer* (Chicago) gives the following method of removing from boilers tubes which have become thickly coated with scale:

If a tube has to be taken out of a boiler, first get a ripper, Fig. 1, which is a cutting chisel, and use it as shown in Fig. 2. A slit about ⅛ inch wide is cut into the tube extending about 1 inch into the boiler. This will allow you to squeeze or knock the end of the tube together so that the end will pass through the hole in the tube sheet, and by being careful there will be small danger of cutting into the tube sheet. Sometimes it is possible to cut tubes so that they can be taken out of the boiler through the hand hole, but in the cases under consideration this cannot be done. When both ends of the tube are cut and the ends squeezed together a little, the work is not ended by any means, as the chances are that there will be scale on the tube that will prevent it from coming freely through the hole. Even 1/16 inch of scale will cause a lot of trouble. There are special tools sold by dealers in engineering goods to use for tubes in this condition which I will not attempt to describe, but show in Fig. 3 a home-made article I have used. The ripping tool is used to cut a strip about ¾ inch wide at the back end, instead of ⅛ inch, and the rod shown in Fig. 3, which is just the length of the tube, is slipped through the tube and the end *A* hooked into the cut; *B* is one of the hand-hole bridges, *C* is a washer and *D* is a nut. A long thread is cut on the straight end of the rod, and by turning up the nut *D* the tube is drawn forward. When the tube is out the length of the thread, something must be placed behind the bridge to bring it forward again. A tackle can be hitched directly onto the tube or rod and the whole pulled out. Sometimes a new tube is a loose fit. In this case a lot of expanding can be saved by placing a narrow strip of sheet copper around the tube at the sheet before starting to roll it. Tinned iron is sometimes used, and it will also fill up any small score that may have been made in the sheet by removing the old tube.

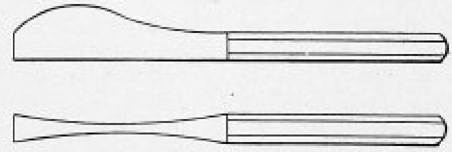


FIG. 1.—RIPPING CHISEL.

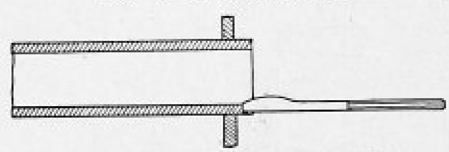


FIG. 2.—METHOD OF USING RIPPER.

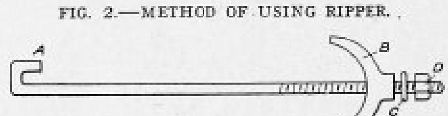


FIG. 3.—DETAILS OF ROD.

PNEUMATIC TOOLS FOR BOILER SHOPS—I.

Important Points on the Design, Operation and Care of Pneumatic Drills, Hammers and Hoists which are Used in Boiler Shops.

BY CHARLES DOUGHERTY.

In writing on the subject of pneumatic tools it is not the intention of the author to express himself from a theoretical or scientific standpoint, but to use such ordinary terms as will be readily understood by practical boiler makers, of whom he is one, and for whom this article is especially intended.

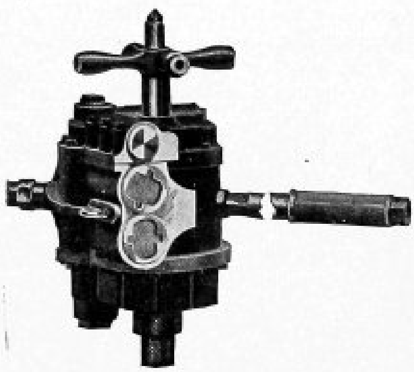


FIG. 1.—THE "LITTLE GIANT" DRILL.

While pneumatic tools have been in use for many years, as an adjunct in the mechanical equipment of up-to-date shops, it is regretable that more of the workmen do not familiarize themselves with the details of construction of the tools that they handle from day to day, and with which, for their own

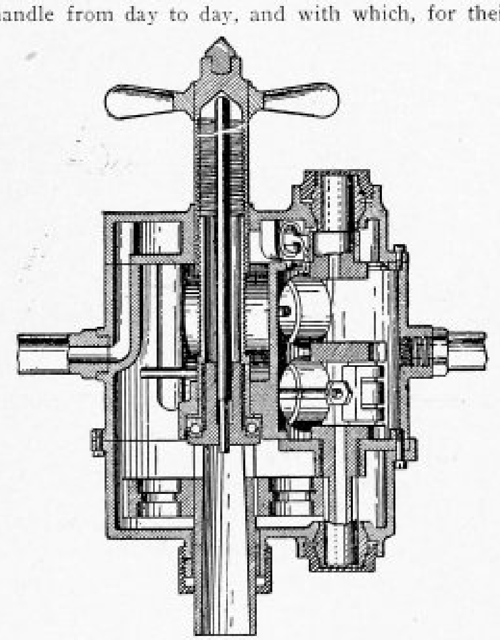


FIG. 2.—SECTIONAL VIEW OF "LITTLE GIANT" DRILL.

sake, they should be more familiar. It is unnecessary to dwell on the economy of pneumatic tools, that is a fact that has already established itself and is beyond dispute.

Drills.

In the manufacture of pneumatic drills, it is necessary to produce a machine having the utmost superiority with the least possible weight and fewest number of parts, capable of transmitting to the spindle the greatest percentage of power in proportion to the amount of air consumed. To accomplish this, the machine must be harmoniously designed throughout and made of the best material by experienced and high-grade mechanics. The accompanying illustrations and descriptions of the various makes of drills should be of value to the user of pneumatic drills, not only in assisting him to ascertain

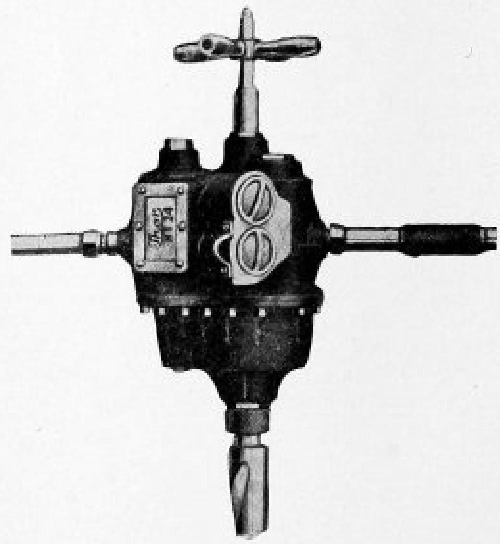


FIG. 3.—THE THOR DRILL.

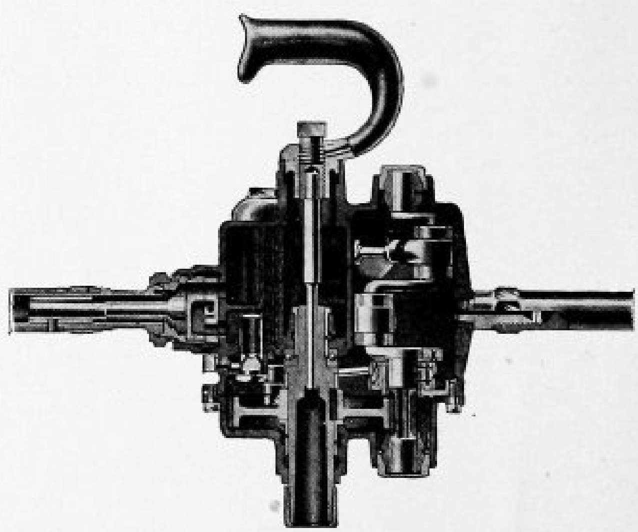


FIG. 4.—SECTIONAL VIEW OF THOR DRILL.

which type is best adapted for his particular uses, but also in helping him to more thoroughly understand the action of the tools so that he may use them more intelligently and take better care of them.

THE "LITTLE GIANT" DRILL.

The "Little Giant" drill, manufactured by the Chicago Pneumatic Tool Company, Chicago, Ill., is of the balanced piston type with four single-acting cylinders arranged in pairs, the pistons being connected to opposite wrists of a double crank-

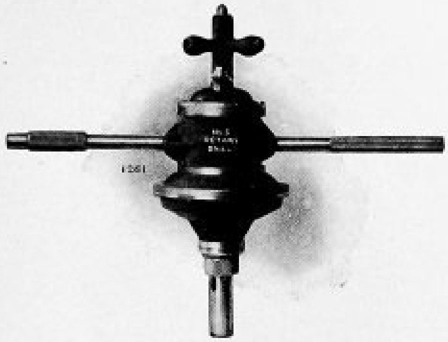


FIG. 5.—HAESELAR ROTARY DRILL.

shaft. The fact that the pistons in each pair travel in opposite directions, causes the smooth, easy running action for which this machine is noted. The admission of air is controlled by means of balanced piston valves set to cut off at ⅝ of the full stroke. This arrangement is designed to give

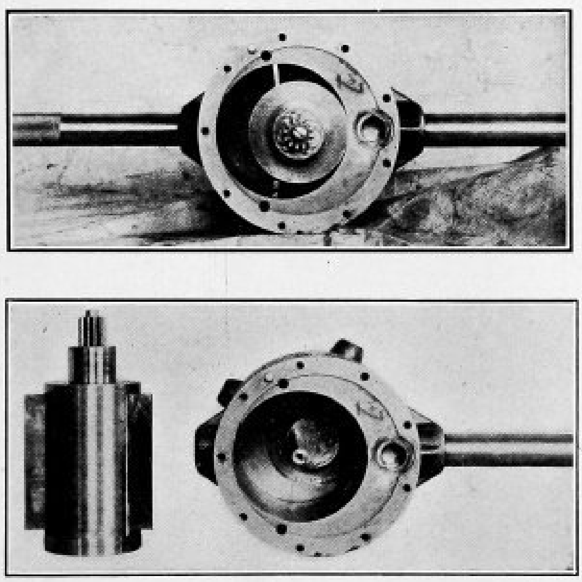


FIG. 6.—INTERIOR OF HAESELAR DRILL, SHOWING PISTON IN PLACE AND REMOVED.

economy in air consumption and yet not sacrifice speed or power. The crankshaft revolves in an enclosed chamber designed to be kept partly filled with lubricant. All of the four cylinders open at their rear ends into this compartment, and the gear case also communicates with and forms a portion of this chamber or oil receptacle. When the machine is in use

FIG. 7.—COMPOUND GEARING IN THE HAESELAR DRILL.

the rapid rotation of the crankshaft throws the enclosed oil over the parts located in the chamber and in the gear case, thereby insuring continuous lubrication of all the parts. Contrary to the custom in many other types of piston drills, the exhaust air does not pass through the working parts. Although such an arrangement insures a cool running tool, yet when used with the system of lubrication used on the "Little

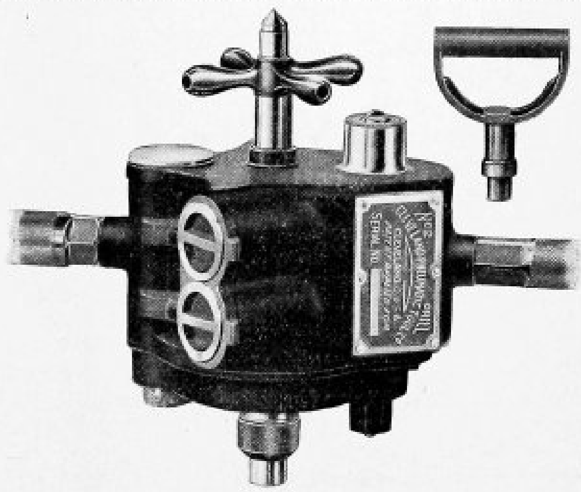


FIG. 8.—THE CLEVELAND DRILL.

Giant" drill there is the disadvantage that it tends to dry the oil, and for this reason the exhaust is not carried through the running parts. The thrust in drilling instead of being applied through the frame of the machine is passed directly from the drill of the feed-screw by means of a spindle, bearing in a fixed post upon which the feed-screw is mounted. It is provided with standard Morse taper sockets, and the drills

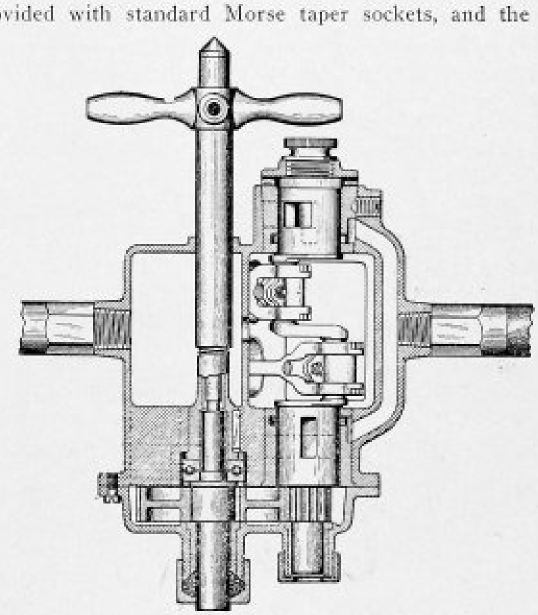


FIG. 9.—SECTIONAL VIEW OF THE CLEVELAND DRILL.

are extracted from the socket by screwing down upon the feed-screw when the point of the spindle bearing on the end of the drill forces it outward. This avoids the necessity of hammering a key into the chuck to loosen the drill with the consequent danger of jarring the parts.

THE "THOR" DRILL.

The general features of the "Thor" drill, manufactured by the Independent Pneumatic Tool Company, Chicago, Ill., are clearly outlined in the accompanying illustrations. This drill can be distinguished at a glance from the "Little Giant," which has just been described by the two-piece casing and rounded top edges. All "Thor" pneumatic drills are of the four-cylinder reciprocating piston type, the cylinders being connected to a two-way opposed crankshaft. The valves are of the Corliss type, set parallel to the crankshaft and very close to the cylinder heads. This allows the live air to be magazined and controlled up to within ⅜ of an inch, or less, from the cylinder, which, when released quickly, acts on the pistons instantaneously. This construction allows no air to

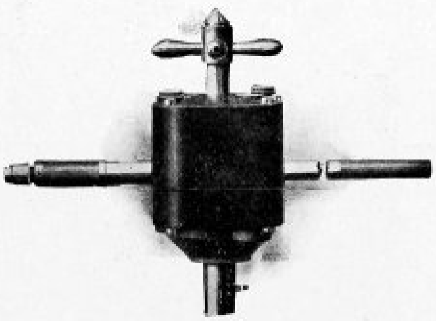


FIG. 10.—THE MONARCH DRILL.

pass through the motor except what is absolutely needed and used in driving the tool, a point which has an important bearing on the economy in air consumption.

The pistons work in a steel casing, which is in one piece, and as there is only one joint between this casing and the gear case there is little opportunity for the working parts to get out of alinement or for leakage to occur.

The crankshaft has three bearings and as no eccentric is attached to it the bearings are close to the crank throws at both ends, and also close to the pinion on each side. The eccentric is carried on a separate housing parallel and concentric with the center bearing, a construction designed to save space in the length of the drill, equal to the length of the eccentric, as well as providing another bearing which makes

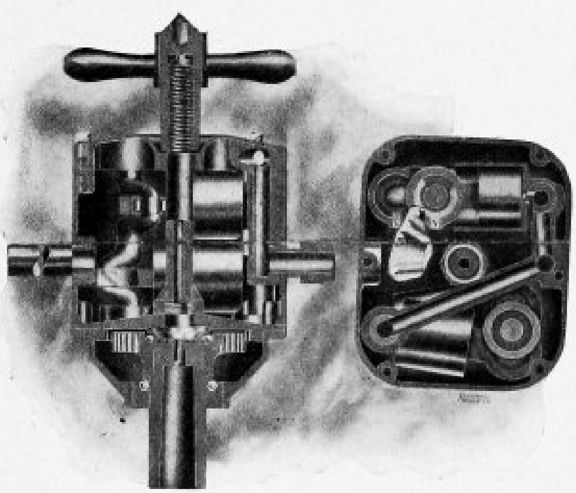


FIG. 11.—SECTIONAL VIEW OF MONARCH DRILL.

four bearings for the crank and eccentric. The main object of this construction, however, is to provide an eccentric bearing that is entirely independent of the wear of the crank bearings proper.

The screw feed in these drills is telescopic, having three members, one working inside of the other, a common arrangement for obtaining an extremely long range of feed from short space.

HAESELER ROTARY DRILL.

Some progress has been made in the development of the rotary type of drill as opposed to the off-center reciprocating piston type. Theoretically this type of drill should result in a steady-working, powerful machine, such as would be particularly adapted to reaming, tapping, etc. The illustrations of the Haeseler rotary drill, manufactured by the Ingersoll-Rand Company, New York, show the construction of such a drill. The thing that first suggests itself upon seeing this drill is the small number of parts and extreme simplicity of construction. The body, or casing, forms the working cylinder, which contains a cylindrical piston mounted eccentrically. The rotation is obtained by means of blades in this piston.

Fig. 7 shows how the power of such a machine may be increased by the use of compound gears without destroying the balance of the motor. The piston shown in Fig. 6 is inserted between the idler gears mounted on the idler frame, on the under side of which are gears meshing with an annular gear from which the compound power is derived.

CLEVELAND DRILLS.

The "Cleveland" drills, manufactured by the Cleveland Pneumatic Tool Company, Cleveland, Ohio., are of the four-cylinder type, and have four single-acting pistons arranged in pairs, each pair of pistons being connected to opposite wrists

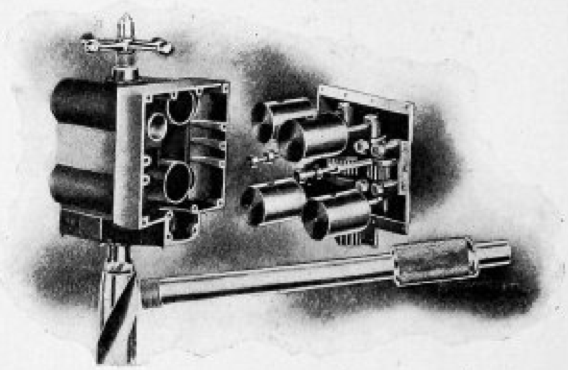


FIG. 12.—THE PITTSBURG DRILL.

of a double crankshaft. These drills, while essentially similar to other piston drills in their action, have several unique features. The cylinder body is in one piece with hand-hole openings in the crank case. These openings give immediate access to the crank connections and other vital parts of the mechanism. The valve is of the duplex rotating type in one piece and controls all four cylinders. This style of valve gives equal distribution of air to all cylinders and is extremely simple. In the non-reversible drills the valve consists of one piece, while in the reversible drills it consists of two pieces. These drills exhaust to the outside, thus affording an opportunity, as in the "Little Giant" drill, of maintaining a sufficient quantity of oil in the interior of the case to assure proper lubrication. Another unique feature is the method of connecting the pistons by means of a ball and socket joint, in order to reduce to a minimum the chances of the pistons binding in the cylinder. The cranks are of a novel type, inasmuch as they are provided with an internal passage for oil, which receives its supply from a sort of reservoir formed by the hollow upper portion of the crank.

The thrust is not borne by the main frame of the machine, but passes direct to the feed screw by means of a spindle bearing in a fixed post upon which the feed screw is mounted.

PITTSBURG DRILL.

A drill in which accessibility is gained in an entirely different way is that manufactured by the Pittsburg Pneumatic

Tool Company, Pittsburg, Pa. This is also of the four-cylinder reciprocating type. Its pistons are attached to a cap, which may be readily unscrewed from the case in a few minutes. The working parts are thus exposed to plain view and the operation of assembling may be easily carried out, as there is no guesswork as to whether the various parts are properly secured in place. The cranks are all of the same pattern and in one solid piece. The valves are of the balanced piston type. Aside from the feature of having the mechanism attached to the cap, which prevents the possibility of mistake in reassembling when repairs are necessary, this drill is supplied with a governor, which controls the supply of air automatically and prevents excessive speed when running light.

MONARCH DRILLS.

The Monarch drill, which is a product of the Standard Railway Equipment Company, of St. Louis, Mo., is of the piston type, having stationary valves and oscillating cylinders. In this drill the rod, strap and piston are combined in one piece, thus transmitting the thrust direct to the crankshaft, and reducing the number of parts with the consequent loss in friction. The drill differs from others of the reciprocating piston type, in that the cranks are equipped with roller bearings throughout, which the makers claim avoids the necessity of providing means of lubrication by running in a bath of oil. It will be seen from this that all makers are not agreed as to the best method of lubrication, some being strong advocates of the oil bath, while others favor the intermittent method of oiling. The valves are of such construction that they compensate for wear. The thrust in this type is not obtained through the casing, but is transmitted direct from the feed screw to the spindle, the casing being necessary only to protect the moving parts.

(*To be continued.*)

A Family Gathering in a Boiler Shop.*

BY "SHIPYARD PICKLING."

Not many months ago there was gathered in a large boiler shop down near the water front a number of representatives of the marine branch of the well-known Boiler family. Reunions in this branch are, as every one well knows, very few and far between, as the members are all hard workers, and do so much traveling that it is seldom they have a chance to meet and commune with one another. On this particular occasion there happened to be, for one reason or another, a delegate from about all the important groups who follow the sea for a living. There was old man Scotch, who rejoices in having four furnaces, and a shell so thick that it could in time of necessity almost be used for a protective deck; near him squatted old Mother Waterleg, recently taken out of an East river ferryboat, and who, general gossip claimed, ought to have been hit in the head and drowned years ago. The watertube members were there in plenty, prominent among them being Mr. B. & W., Monsieur Niclausse, "John" Thornycroft, "Yank" Roberts, "Bill" Almy, "J. Bull" Yarrow, "Gus" Mosher, "Doc" Ward and several smaller members. Scattered about in the gathering were "Johnny" Gunboat, "Marine" Locomotive, who seemed rather ill at ease, and away over in the corner, aloof from the rest of the crowd, was "Pop" Doghouse, leaning on his last legs.

At first the conversation was general, various inquiries being made about the health of absent members, and in an exchange of reminiscences of events since the last meeting old man Scotch's voice could be heard above the general buzz of conversation, as he grunted out his opinion of things in general. The fact is, the old man was what might be termed "chesty," due, no doubt, to the fact that the members of his particular family were more numerous than any of the others. His dislike for the watertube branch was quite pronounced, and he never lost an opportunity to sneer at them, and say something sarcastic about the "bundles of gas pipe," as he termed them. B. & W., being the largest of his family, would occasionally fly up and resent some of Scotch's insinuations and insults, and could almost always get a "rise" out of the old boy by calling him a "good old has-been" or a "hard shell Baptist, full of water." Niclausse couldn't speak very good English, but would invariably back up B. & W. by shouts of "Oui! Oui!" until his inner tubes would vibrate. "John" Thornycroft and "J. Bull" Yarrow would yawn their furnace doors open and say, "Oh! what a beastly bore the old chap is, doncherknow."

During a lull in the conversation old Mother Waterleg piped out in her low-pressure voice, "Well, what do all you good boiler people think about the gasoline engine?" Instantly there was a chorus of hisses, as if every boiler present had blown out a tube. "I'm agin' 'em," growled out Scotch; "they are putting too many of our young relatives out of business. If they keep on the way they have been doing it will be mighty hard for our half-grown children to earn a living in these launches and yachts.'

"Oh! come off, Scotch," shouted "Yank" Roberts, "Doc" Ward and "Bill" Almy, in chorus; "what good are *your* half-grown children in a launch or yacht anyhow?" "That's all right," retorted Scotch; "so that's all the credit you give me for standing up for you. Well! what would a boiler jawfest be, anyhow, if some one didn't get out a hammer?"

Aside from this slight interruption it was quite evident that all present were sore on the gasoline engine proposition, and much in the attitude of the Irish orator in New York, who "viewed with alarum the growth of the Girman ilement."

Like their human prototypes, the more garrulous of the boilers began talking of the health of themselves and their friends. Nearly all had some disease or ailment of which to complain. Old man Scotch had a few leaky rivets, dropsy in one of his crown sheets, and complained of a dullness in his heating surfaces. Some of the watertube brethren complained of sagging tubes, leaky joints and pitting in their steam drums. All agreed that their human doctors failed to give them proper medical attention.

Old Mother Waterleg nearly precipitated another outburst of anger among the crowd, by gravely asking them if they did not think they were entitled to as much care and attention as was given to the engines for which they furnished the steam. Unwittingly she had touched upon a very sore subject, as nearly every well-trained boiler thinks that his lot is a hard one compared with his more fortunate brethren of the Engine family.

"The very idea," gasped "B. & W.," "of our doing all the work on board a ship, and the engines getting all the petting and attention from these engineers. Why, every time they stop that old Triple who goes in the same ship with me, they must needs rub him down and then go around and adjust all his parts as carefully as if he were a gold watch. All they do to me is to haul my fires up in a heap, throw a lot of old ashes over them, and let me look out for myself. The only sickness I ever feel is when they fill me up with some nasty old oil which that engine has had to mix in with the steam I give him to keep his rickety old cylinders from grunting. Once in a while when we are running they will condescend to blow the soot off my tubes, but they go at it so slowly that I get a chill from having my cleaning doors opened so long. The first thing they know I'll get a good bilious attack from having been fed too much grease, then I think they will pay me a little more attention. Only the other day I had an attack of acidity in my stomach, but that Second Assistant on

* By courtesy The Bird-Archer Company.

our ship was kind enough to give me a dose of soda. He's a pretty good sort of chap, and if the old man would only let him have his way I know he would take very good care of me."

Old man Scotch gave his approval to those remarks, and said, in furtherance of the ideas advanced by his watertube brother, "If those human masters of ours would only treat us with half the consideration they have for workmen of their own kind, they would find it to be the best investment they ever made. We need to be properly clothed, fed and doctored just as much as men are, and while we can't speak their language, we certainly have a few grunts and hisses that we make use of when we are not properly treated. After all, our diseases are very similar. A man is exposed to the cold and dampness and gets lung trouble or other wasting disease; expose us to the cold and dampness and we split our plates or begin to rust away; if a man is fed on too greasy food he gets bilious and can't do his work; stick a lot of oil or grease into our feed-water and we get bilious and sluggish in our heating surfaces, and can't do half our usual work.

"When a human boiler gets overfed the man starts to smoke, gets dopy and wants to go to sleep; with us, if they fill our furnaces up to the crown sheets with fuel we will do exactly the same things. Of course, when we get in that condition, we are prodded up with long, disagreeable slice bars. I think some of those lazy mortals would get a move on them if they were prodded a little with a slice bar. When a man gets a pain he begins to weep, and others of his kind sympathize with him. How different with us poor devils; if we happen to get a pain in our plates and begin to weep at the seams they dig us in the vitals with one of those boot-legged calking tools, and if we don't stop right off they slap on one of those nasty soft patches, which is ten times worse than a mustard plaster. There's just one disease where mankind gets it just as bad as we do. The human pill doctor calls it smallpox; our doctors call it galvanic action when it attacks us; but whatever it is we both have to carry the 'pock-marks' or 'pittings', or whatever you choose to call it. down to our graves. I understand that some wise guy among the two-legged gentry studied up on this smallpox disease and found some kind of stuff they call vaccine virus, which will prevent the thing from attacking any one who has been vaccinated with it. Now, if some one would just get busy and invent some kind of dope which would keep us from being pitted, we would all be happy."

"Hear! Hear!" shouted the whole metallic family. "Now you are talking sense, Old Man."

It was getting late, and "Thornycroft" and "Yarrow" began to show evidences of getting tired; "Almy" and "Roberts" actually yawned, whereupon Old Scotch chided them for disrespect to him during his lecture.

"Say, fellows," chimed in young "Mosher," "I've got a conundrum for you. Why is this old 'Papa' lecturer, when he is being treated for acid in his stomach, like a high-ball?"

"Give it up," said one after another.

"Oh! it's easy," sarcastically remarked Mosher; "it's simply because he is a combination of Scotch and soda!"

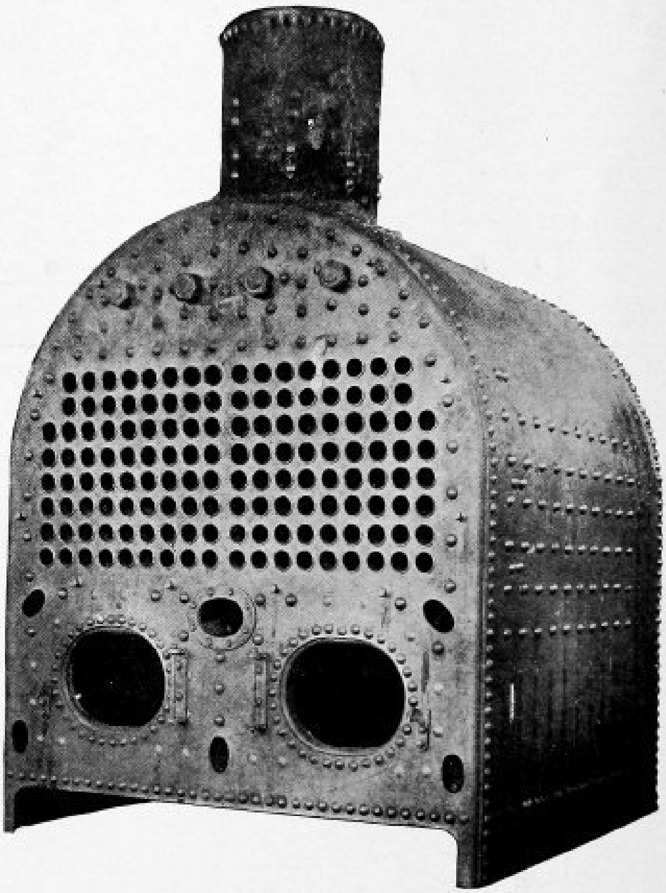
Even old Frenchy Niclausse snorted out his rage at such a horrible pun, and presently peace reigned over the shop, as every one had gone to sleep.

Boilers require for each nominal horsepower about 1 cubic foot of feed-water per hour. Locomotives average a consumption of 3,000 gallons of water per 100-mile run.

The best designed boilers, well set, with good draught and skillful firing, will evaporate from 7 to 10 pounds of water per pound of best quality coal. The average result is from 25 to 60 percent below this.

The Dog House Boiler.

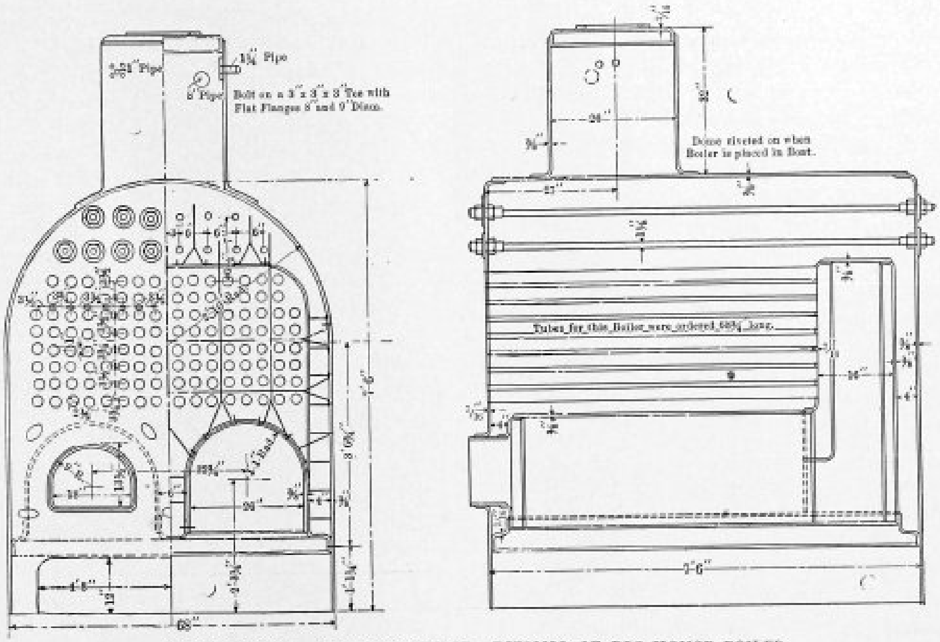
Replace the cylindrical shell and furnaces of a Scotch marine boiler by a shell and furnaces which have cylindrical tops and flat sides, and the result is the type of boiler which is commonly known as the dog house boiler. The particular boiler, of which a photograph and drawings are shown on this page, was constructed by P. Delaney & Company, Newburgh, N. Y., for use on a steam canal boat. It is 7 feet 6 inches long and 7 feet 6 inches high with a steam dome 26 inches in diameter by 32 inches high. It is designed to carry a steam pressure of 110 pounds. There are two furnaces each 26 inches wide and 70 inches long made of 3/8 inch steel plate. The gases from



A TWO-FURNACE DOG-HOUSE BOILER.

both furnaces enter a common combustion chamber at the back of the boiler and from there are led back to the up-takes through 124 ordinary 2½ inch tubes.

The lower edges of the furnaces and combustion chamber are joined to the shell by a 7/16 inch S-shaped flanged plate, leaving a 4-inch water leg all around the lower part of the furnaces and combustion chamber. The flat plates throughout this water leg are stayed with ordinary screw staybolts. The top of the shell due to its cylindrical shape is capable of resisting the internal pressure of the steam without any further bracing, but the entire lower part of the boiler which includes the tops of the furnaces and combustion chamber is little adapted to resist this pressure and therefore must be strongly stayed from the outside shell. This is accomplished by means of long sling stays attached at both ends with crow feet. The segment of the boiler head above the tubes is braced in the ordinary manner by means of direct through stays 1⅛ inches in diameter spaced 6 inches between centers, the ends being secured by inside and outside nuts and washers in the



LONGITUDINAL AND TRANSVERSE SECTIONS OF DOG-HOUSE BOILER.

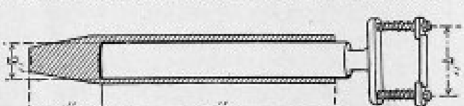
usual manner. The shell of the boiler is made ⅜ inch steel plate with heads and steam dome of the same thickness.

As a problem of laying out this boiler presents no unusual features, if the layout of a Scotch boiler is well understood. The length of the shell plate can easily be obtained by getting the length of the line at the center of the thickness of the material. This is simply the length of the two flat sides, each of which is 4 feet 8 inches long, plus the length of the semicircle whose diameter is 67⅜ inches. The heads and combustion chamber are laid out in the usual manner except the combustion chamber is left open at the bottom so that the plates may be riveted directly to the flange connection which joins them to the shell plate and back head. In place of the ordinary corrugated cylindrical furnaces, it is necessary to lay out two plates of similar form to that of the shell plate. The back tube sheet fits down over the furnaces, the lower corners of the plate being scarfed where the wrapper plate and furnace sheet join.

The furnace doors may be made in any desired shape; round, oval or of the same shape as the furnace. Perhaps the simplest construction is to make them oval as shown in the photograph, inserting a flanged ring between the front head and the end of the furnaces. This avoids the necessity of flanging the door hole in the boiler head and also in the furnace head.

A Holding-On Bar.

An interesting holding-on bar for rivets up to ½ inch is in use in the McKees Rocks boiler shop of the Pittsburg & Lake Erie Railroad, and is shown in the illustration. The springs not only relieve the shocks and make it easier for the man,



A NEW IDEA FOR A HOLDING-ON BAR.

but it is possible to drive the rivets faster, since the bar returns more quickly to the head of the rivet when the shock jars it. The bar was devised by Mr. John B. Smith, foreman of the boiler shop.

The Nature of True Boiler Efficiency.*

BY W. T. RAY AND HENRY KREISINGER.

The Steam Engineering Division of the United States Geological Survey, in conducting boiler tests for the purpose of determining the heat values of coal for steaming purposes, found early in its experiments that the results obtained would have but little meaning unless the boiler performance were subtracted or divided out so as to get the efficiency of the grate and furnace. The purpose of this article, which is largely an abstract from a bulletin prepared by the above named division, is to offer a few formulated laws governing the rate of heat absorption by boilers and to present the more important results of these experiments.

HEAT TRANSMISSION.

Heat travels from any hot body only to bodies at lower temperature; therefore, any boiler can absorb only that heat which is above the temperature of the water in it; heat below this temperature will not flow into the boiler water and therefore is not available for absorption. Commercial boilers absorb only part of the heat which is available for them; the percentage of the available heat which is absorbed by the boiler is called the true boiler efficiency. This efficiency depends somewhat on the way the heat is presented to the boiler, but chiefly on the construction of the latter. The true boiler efficiency is then defined as the ratio of the heat absorbed by the boiler to the heat which is available for it, counting only that heat available which is above the temperature of the boiler water.

In the diagram, Fig. 1, if the horizontal line represents the volume of gas and the vertical line temperature, then the total heat in the gas will be represented by the area *OEFP*. If *A* represents the temperature of the steam, then that part of this area below the line *AB* is not available. The available heat will then be represented by the area *AEFB*, and if *G* represents the temperature of the flue gas, the amount used will be represented by *GEFH*, so that the efficiency will be represented by the area *GEFH* divided by the area *AEFB*. If twice as much air be used, so that the volume of gas will be *OP'* and

* Abstract of paper read before the Western Society of Engineers, Chicago, Sept. 18, 1907.

the temperature half as high or at E', then the efficiency will be area $GE'F'H'$, divided by area $AE'F'B'$, which is evidently less than in the first case, showing that a high furnace temperature gives a high efficiency and a large air volume low efficiency. If the line AB should be raised, as it would be by increasing the boiler pressure, the available heat will be cut down so that the efficiency will be increased, provided, of course, that the final temperature of the gas remains the same.

In any steam generating apparatus the heat is evolved by the burning of fuel in the furnace, and is then transmitted

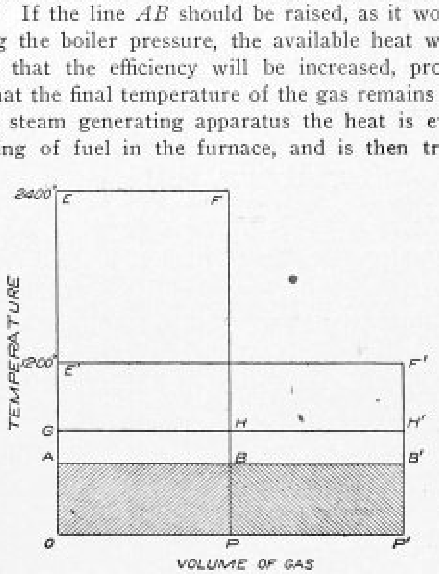


FIG. I.—TRUE BOILER EFFICIENCY DIAGRAM.

through the space and through the water-heating plates into the boiler water. The path of the heat travel and the mode of the transmission are shown in the accompanying diagram (Fig. 2).

In practice, the water-heating plate of the boiler is always, to some extent, covered on the outside with a coating of soot, and on the inside with a layer of scale or mud. Just on the outside, and entangled in the small recesses of the soot coating, is a dense film of gas which adheres to the solid. The density of this gaseous film decreases outward from the solid layer of soot. It is somewhere within this gaseous film where the dry surface of the water-heating plate can reasonably be assumed to exist. There is a similar film of steam and water, adhering to the layer of scale on the inside of the boiler, which film can be considered to contain the wet surface of the heating plate.

In the diagram it is shown that heat is communicated to the dry surface of the water-heating plate mainly in two ways:

a. By radiation from the hot fuel bed and furnace walls.

b. By convection from the moving gaseous products of combustion. By convection is meant here the process of displacing cold molecules from the adhering film of gas by hotter ones from the moving mass of hot gases.

From the dry surface of the heating plate, the heat is transmitted through the layers of gas, soot, metal, scale and steam to the wet surface purely by conduction. From the wet surface the heat is carried into the body of the boiler water mostly by the convection of the circulating water. The retardation of any one of these three modes of heat travel lowers the efficiency of the boiler.

RATE OF HEAT RADIATION AND CONDUCTION.

Although this paper is intended to discuss mainly the factors which influence the rate of heat impartation by convection, a brief explanation of the laws of the rate of heat radiation and the rate of heat conduction will help in making clear the whole matter of heat absorption by the boiler.

The quantity of heat which the boiler receives by radiation from any hot portion of the furnace or the fuel bed may be taken to be proportional to the difference of the fourth powers of the absolute temperatures of the hot parts of the furnace and the soot coating on the boiler plate. This law of radiation is known as Stefan & Boltzmann's law. Strictly speaking, it applies only to black bodies; however, within the usual temperature range of the boiler furnace it can be applied to boiler problems without any serious error. It shows that the quantity of heat received by the boiler by radiation increases very rapidly as the temperature of the furnace rises. In boilers where the heat received by radiation is a predominant part of the total heat absorbed, the true boiler efficiency necessarily increases with the rise of the furnace temperature.

The quantity of heat which can be transmitted through a given unit of water-heating plate in a unit of time depends on the difference of the temperatures of the dry and the wet surfaces of the heating plate, and the conductivities of the substance between the two surfaces. For instance, if it is required to transmit double the quantity of heat in the same length of time the difference of the temperatures of the two surfaces must be doubled. Since the temperature of the wet surface is nearly the same as that of the steam in the boiler, and therefore can not be lowered, the temperature of the dry surface must be raised; as it is this dry surface of the heating plate which cools the furnace gases, the rise of its temperature results in the rise of the temperature of the escaping gases. Thus we see that with the same conditions of the heating plate and the same initial temperature of the furnace gases, the temperature of the escaping gases will rise with increasing capacity, thereby decreasing the efficiency of the boiler in corresponding degree.

SURFACES OF HEATING PLATES SHOULD BE KEPT CLEAN.

The main cause of unnecessarily great differences between the temperatures of the dry and wet side of the plate and the consequent high temperature of the waste gases is the presence of soot and scale on the surface of the heating plate.

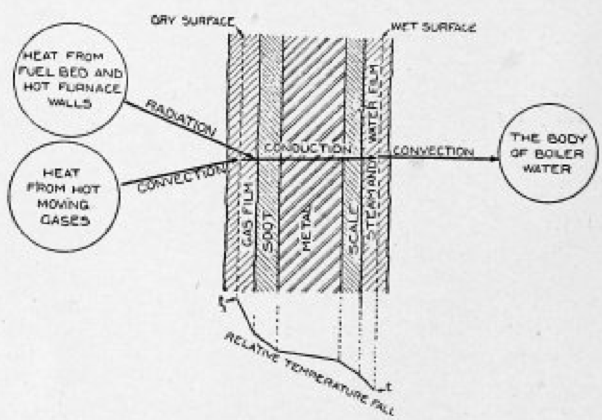


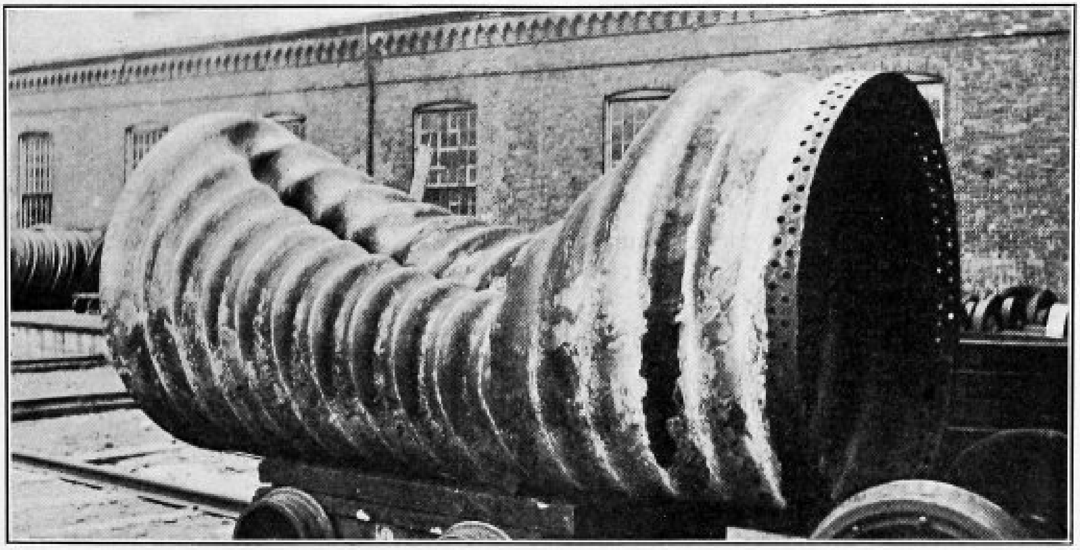
FIG. 2.—PATH OF HEAT TRAVEL FROM GASES TO WATER.

The heat conductivity of both these substances is very low, which fact emphasizes the importance of keeping the surfaces as free from such deposits as possible.

The heat imparted to the boiler by convection forms in most cases a large percentage of the total heat received. It is therefore very desirable, for the sake of better boiler construction and operation, that the factors which influence the rate of heat impartation by convection be more thoroughly known. The Steam Engineering Division of the United States Geological Survey recently started an investigation of this problem, as an incidental feature in its regular work in testing the quality of coals for steaming purposes.

RESULTS OF THE GEOLOGICAL SURVEY'S TESTS.

As the result of a large number of careful tests, one of the most important observations made was that the heat absorbed



VIEW SHOWING COLLAPSED CROWN OF CORRUGATED LOCOMOTIVE FURNACE.

by the boiler per second varies almost directly as the calculated initial velocity of air. With the same initial velocity of air, tests with higher temperatures show a higher rate of heat absorption; but as the initial temperature of the air rises, the rate of heat absorption does not increase in proportion to the temperature, and it is therefore probable that when very high temperature has been reached there is little or no gain in the heat absorbed by further rise in temperature. This fact indicates that the rate of absorption is influenced by another factor, which varies inversely as the temperature; this factor is the density of the gas.

It was also demonstrated from tests conducted that true boiler efficiency drops at first very rapidly when the difference of drafts increases; but when the latter reaches a certain value, which varies with size of tubes and degree of temperature, the efficiency remains nearly constant. The small gradual drop noticed in the efficiency beyond the point where the latter remains nearly constant may be accounted for by rapidly increasing capacity.

It was also noticed that a given difference of drafts pulled practically the same amount of air through two boilers in which the tubes, of same diameter, in the one were nearly twice the length of those in the other. This would seem to indicate that most of the resistance is at the entrance of the flues and very little of it in the tubes themselves, so that increase in the length of the flues increases the total resistance but slightly. Further tests yielded results that would indicate the superior true boiler efficiency of the smaller diameter flues over those of the larger diameter.

DEDUCTIONS.

The deductions drawn from these experiments, briefly summarized, indicate that:

a. After the velocity of gas parallel to the heating surface has reached a certain value, the rate of heat absorption is almost proportional to the velocity.

b. The rate of heat absorption increases when the initial temperature rises; it also seems to vary directly with the density of the gas.

c. Increasing the diameter of flues decreases the efficiency of their absorbent power; increasing the length of flues beyond a certain limit increases their efficiency very little.

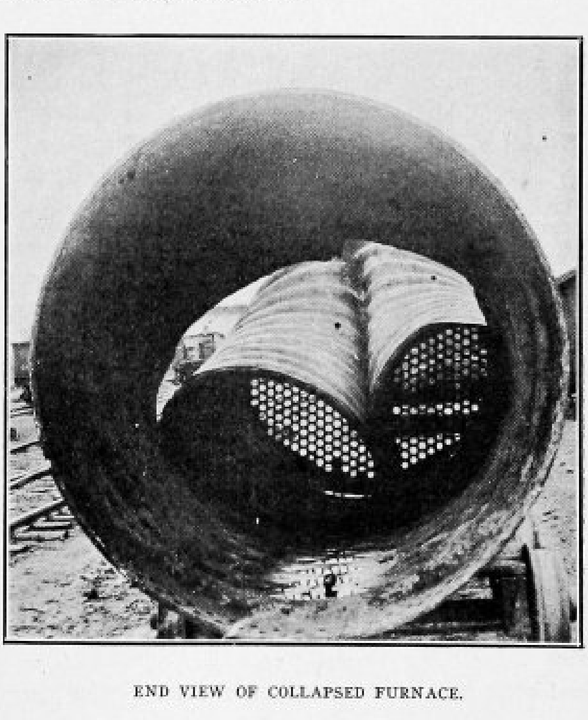
d. Most of the resistance to the passage of air through the flues is at the entrance into the tubes; the length of the flues increases the resistance but little.

The Collapse of a Corrugated Furnace.

BY A. B. DOUGLAS.

Two views are shown herewith of a cylindrical corrugated furnace which collapsed from low water. The principal dimensions of the furnace are as follows: Diameter, 65 inches; length, 133 inches; thickness, 13/16 inch. The furnace was used in a locomotive boiler, 88 inches in diameter, which contained 517 flues 1¾ inches in diameter by 11 feet in length, working under a steam pressure of 190 pounds per square inch.

The explosion occurred while the locomotive was in service, and resulted in two fatalities as well as the destruction of considerable rolling stock. A space about 18 inches wide and the full length of the furnace was red-hot and gave way, as shown in the photograph. An opening about 8 feet 6 inches long was torn circumferentially under the hole of the sixth corrugation from the rear end of the furnace. No other damage was done to the boiler.



END VIEW OF COLLAPSED FURNACE.

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - - New York

Christopher St., Finsbury Square, London, E. C.

H. L. ALDRICH, President and Treasurer

S. W. ANNESS, Vice-President
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HOWARD H. BROWN, Editor

Branch Offices.

Philadelphia, Pa., Mach'y Dept., The Bourse, S. W. ANNESS.
Boston, Mass., 170 Summer St., S. I. CARPENTER.
Chicago, Ill., 625 Monadnock Building, H. S. MOSS.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico........	$1.00	.10
Other countries in Postal Union..........	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

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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.

Good Boiler Steel.

The complaint is frequently heard that boilers which are manufactured to-day do not stand the test of time on account of the inferiority of the materials of which they are made. Numerous samples taken from boilers built twenty or thirty years ago are exhibited which show that in the majority of cases the steel of which those boilers were constructed was of exceptionally good quality and particularly well adapted to resist corrosion and the general hard usage which boilers must withstand. Such specimens are compared with test pieces taken from modern boilers, which have been in service only a comparatively short time, but which have shown marked deterioration, due either to the action of corrosion or through some defect brought out in working the metal. These facts are not confined solely to boiler materials, but the same complaint is frequently heard from manufacturers who use other grades of steel for commercial purposes. It would seem strange, indeed, that with all the progress which has been made in recent years in the manufacture of iron and steel it should be impossible, for purely mechanical and physical reasons, to produce steel of as good a quality as that which was made a quarter of a century ago.

Good steel can be produced, and the fact that boiler manufacturers find it difficult to get it is due to several reasons. In the first place most of the steel which was used in steam boilers twenty or thirty years ago was made by the crucible process. By this process, however, only comparatively small sized plates can be rolled, and since the high steam pressures which are used to-day prohibit the use of small plates and numerous riveted joints in boilers, it is evident that some other process of making steel must supplant the crucible process. In other words, quality is sacrificed to quantity. By the open-hearth process which is used in making mild steel boiler plate to-day, nearly as good steel can be produced as by the crucible process, notwithstanding the false impression which many steel users have that scrap of an inferior quality is used in this process in the efforts of steel manufacturers to turn out a large quantity of material. The rigid, physical and chemical requirements of the specifications to which boiler plate must conform make it hardly possible to use inferior scrap in its manufacture.

Another fact which makes it difficult for boiler manufacturers to get good boiler steel is that the price of plate has been forced down from $5.00 to $1.70 per hundred pounds, and steel manufacturers find that they cannot make plate which will come up to the requirements of the specifications without losing money on it. The demand for common steel products for which suitable steel can be easily made is so great that steel manufacturers are compelled to give first attention to meeting this demand, since it is more profitable.

Boiler manufacturers are willing to pay a good price for good boiler steel, and have prescribed certain specifications to show what shall be considered as good steel. These specifications are fair both to the boiler maker and to the steel maker, and agree very well with the standard adopted by the steel makers in this country. There are, however, some specifications for boiler plate, notably those prescribed by the United States Government for marine boilers, which are manifestly unfair, and which impose conditions on the steel makers so stringent that it is almost impossible for them to manufacture plate which shall come up to such a standard without losing money on it. When the boiler maker is willing to pay a good price for the steel, he should have no trouble in getting satisfactory material, if he will stand up for his rights and demand that the product shall fulfill completely the requirements of the specifications to which it is made. These specifications are a necessary source of protection to the boiler manufacturer and to the steel user, but they may become a burden if not formulated wisely and reasonably.

Much has been done in the past by the American Boiler Manufacturers' Association of the United States and Canada towards supplying the general trade with better materials, and that the subject is a very live one with them to-day, is evidenced by the amount of discussion brought out regarding it at their recent convention in Atlanta. The positions of the boiler manufacturer and the steel manufacturer do not seem to be antagonistic; rather there is a mutual desire on the part of both parties to accomplish the same result, namely, to better the quality of the steel which is used for boiler construction to-day. The boiler manufacturers are firm in their stand not to use any but the best of materials, such as they know can be produced, while on their part the steel manufacturers are willing to manufacture steel according to any reasonable specifications if they can do it with profit, but most of them refuse, and rightly, too, to attempt to fulfil impractical and needlessly stringent specifications.

TECHNICAL PUBLICATIONS.

Laying Out for Boiler Makers. Size, 10 by 13 inches. Pages 191. Illustrations 432. THE BOILER MAKER, New York, 1907. Cloth bound. Price, $4.00.

This book, which has been largely reprinted from the pages of THE BOILER MAKER, has been compiled for the purpose of giving the practical boiler maker all the information relating to laying out in detail different types of boilers, tanks, stacks and irregular sheet metal work. While the work of laying out, as it is carried on in a boiler shop, requires considerable technical knowledge in addition to that gained by a practical mechanic in the course of his experience in the shop, yet a complete mastery of such subjects as geometry, mechanics and similar branches of elementary mathematics is not essential for doing the work. For this reason no attempt has been made to present these subjects separately from a theoretical standpoint. In this way confusion is avoided in the mind of the apprentice who may not be thoroughly conversant with these subjects, and at the same time those rules which he absolutely needs are placed before him clearly, so that if necessary he may follow them to the letter and obtain correct results. The contents of the book include only those problems which are of practical use to boiler makers in their everyday work, and, as far as possible, the details of each problem are given in full, so that each layout is complete.

The first part of the book is given over to a number of rather simple and elementary problems, which show the methods of laying out by orthographic projection and triangulation, as well as giving numerous practical points regarding the best methods of doing the work and the behavior of the material, which may be expected when it is shaped according to the lines laid down by the layer out. The succeeding chapters take up the layout with greatest detail of the ordinary plain tubular boiler, Scotch boiler, and the locomotive boiler. In addition to the description of the real work of laying out, the necessary calculations are given to enable the workman to figure out the strength of the boiler. A very suggestive chapter is given on the repairs to different types of boilers. While this is, of course, by no means a complete description of such work, yet it contains much practical information that is of importance. The final chapter consists of a series of miscellaneous problems collected from widely scattered sources and comprising much of the work, both usual and unusual, which a boiler maker will meet in the course of his experience.

This book should fill a long felt want in the boiler making field, as it is, so far as we know, the only thoroughly practical work covering this subject, which is one about which boiler makers have always found it difficult to obtain information.

The Blacksmith's Guide. By J. F. Sallows. Size, 4½ by 7 inches. Pages, 157. Illustrations, 165. 1907, Brattleboro, Vt.: The Technical Press. Price, bound in cloth, $1.50; bound in leather, with round corners, $2.00.

This little work, which is of convenient size to fit into the pocket, has been prepared by a blacksmith of years of experience, whose specialty has been along the line of hardening and tempering of tools. The work contains valuable instruction on forging, welding, hardening, tempering, treatment of high speed steel, case hardening, annealing, coloring, brazing and general blacksmithing. The methods described in its pages have been developed and tried out by the author during many years of practical work, and deserve consideration from all firms doing machine work, and all skilled mechanics along this particular line. The processes used by the author in hardening the tools for machine shop work are unique, and are said to have been remarkably successful in competition with similar tools treated by methods commonly known and generally followed

Three of the plates are colored, showing varying degrees of heat and temper, as well as the effects obtained by methods of case hardening and coloring. The other illustrations are largely line drawings, showing how various operations are performed, and illustrating the tools used and the products obtained by the various processes described.

COMMUNICATIONS.

Capacity of Circular Tanks.

EDITOR THE BOILER MAKER:

I send you a rule I have for getting the capacity of circular tanks. It is simple and accurate. Supposing we had a tank to build 10 feet in diameter and 10 feet high, and wanted to know how many gallons it would hold. Square the diameter and multiply by the height. Multiply that product by 47 and divide by 8, as per example:

```
     10
     10
     --
    100
     10
    ----
   1000 cylindrical feet
     47
    ----
   7000
  4000
  ---------
8)47000(5875 gallons
  40
  --
   70
   64
   --
    60
    56
    --
     40
     40
     --
```

If for barrels, square the diameter, and multiply by the height, multiply by 373, and divide that product by 2000. Example

```
         1000
          373
         ----
         3000
        7000
       3000
       ------
2000)373000(186.5
     2000
     -----
     17300
     16000
     -----
      13000
      12000
      -----
       10000
       10000
```

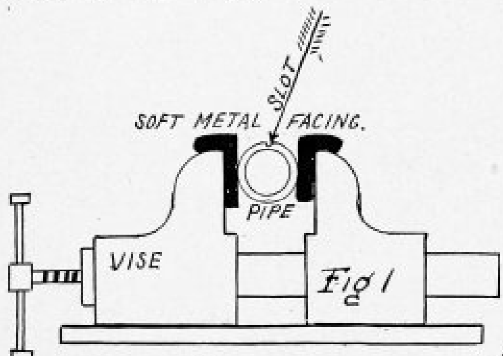
It is a poor rule that won't work both ways. Supposing we had to build a tank to hold 186½ barrels, and the height given as 10 feet. By multiplying the number of barrels by 2000, and dividing by 373, will give us the cylindrical feet. That, divided by 10, the height given, will give the square of the bottom diameter, and the square root of that is 10. Example:

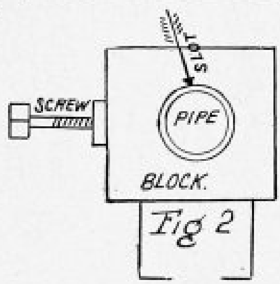
```
          186.5 barrels
          2000
          ————
     373)373000.0(1000 cylindrical feet
          373
          ————
          0000
          height 10)1000(100
                    100
                    ——
                     100(10 diameter
                     100
                     ——       JOHN COOK.
```

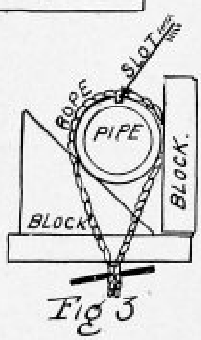
Keywaying or Slotting of Boiler Pipes.

EDITOR THE BOILER MAKER:

The accompanying diagrams represent various ways employed for splining or keywaying steam boiler pipes and tubes. Probably the most unscientific method is illustrated in Fig. 1. I noticed a man in a boiler shop arranging a pipe in a vise for the purpose of slotting it. He desired to get the slot running along the pipe at the point indicated by the arrow. First he secured the soft metal facings, represented in black in the cut, and these were arranged over the jaws of the vise to prevent the hard faces of the jaws from cutting into the pipe wall. The soft metal prevents abrasions, but does not overcome crushing the pipe. In this particular case, the pipe was plainly depressed by the pressure of the facings. The bulging pipe had to be worked on for quite a time with mandrils and various devices in order to restore the walls to proper order.

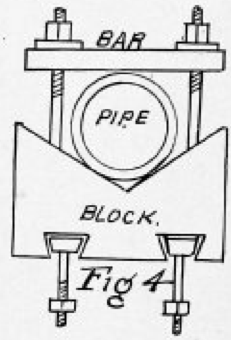


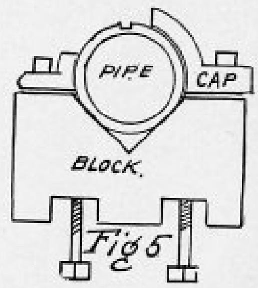


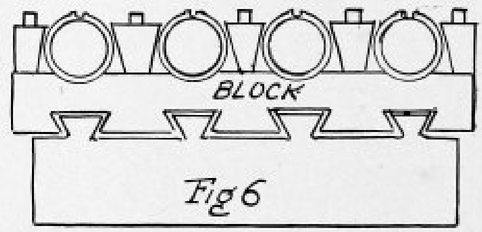


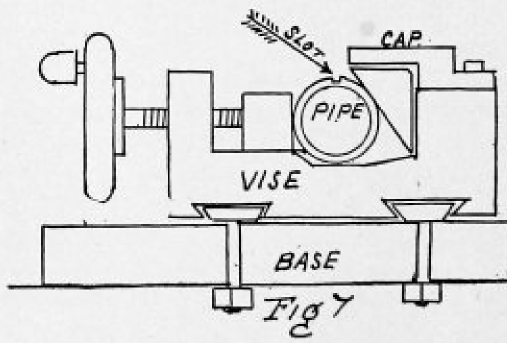
Therefore the method suggested in Fig. 2 has been utilized to advantage in some boiler shops. A block is made from iron or steel, and this is bored through to receive the pipe. Bushings of various diameters are kept in stock for prompt use on different sizes of pipes. The pipe is inserted in the bore of the block, and the set-screw point is turned enough to make the point fasten the pipe in position. The slotting is then done on the planer by bolting the base of the block to the planer in the usual way. The process is imperfect, in that the slotting cannot be done directly at the support. The cutting tool is used only on either side of the block.

Hence we find that, in order not to cover the upper portion of the pipe, various plans are executed. Fig. 3 illustrates one system the writer observed in service in a shop where they were keywaying some pipes for boilers and connections. The blocks were fixed with bolts in the position indicated, and the pipe held firmly between the surfaces by using a strong rope. The rope passes over the pipe and is turned tightly below the frame by a short stick. The same principle, worked out to a more convenient plan is exhibited in Fig. 4. The bother with this arrangement is that the cross bar on top is in the way for splining the work full across. The cutting tool can be worked only on either side of the bar. To complete the cut, therefore, the bar must be reset so as to let the point of the tool to get below it.



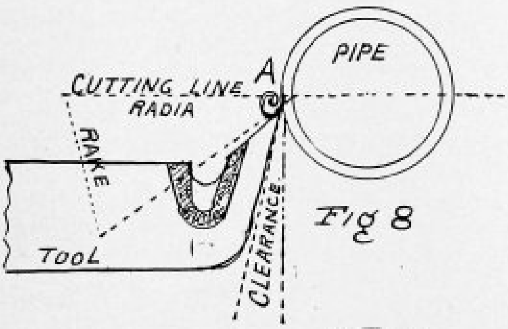


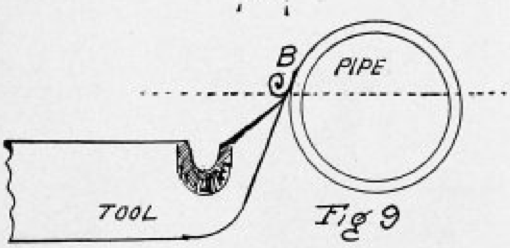


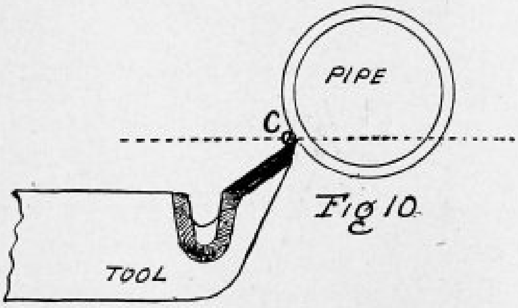


Hence the ingenious man works out a device something after the order of that shown in Fig. 5, in which a clear upper surface is made for the cutting instrument. This form of block can be used to advantage for slotting all round work on planers and milling machines. The milling cutter or planing tool can be passed along the work indefinitely, which is not the case in devices in which top adjustments are provided. Still there is certain work in which the upper supports are essential. On the other hand, it is possible to run a series of slots on pipes adjusted in rotation, as in Fig. 6. Sometimes it is desirable to mill three to five tubes simultaneously. The inverted V-shaped blocks are secured to the base piece by means of separate setting screws, as shown. The upper surfaces of the pipes are fully exposed to the cutting tools.

In Fig. 7 is shown a home-made form of clamping vise with supplementary jaw and inclined side-piece, by which the pipe or tube may be securely retained in position for slotting or for performing kindred work. In fact, practically all of the devices exhibited in these drawings may be utilized for various lines of work, in cases in which pipes or tubes must be retained firmly on line in a certain position. In the device in Fig. 7, the work is prevented from rising out of line when undergoing the slotting, because of the pressure exerted on the pipe by the tapering block beneath the cap. Blocks of various dimensions may be adjusted here. Hence the use of the adjustable cap, which may be removed so that the required style of block may be dropped in. Then the cap is reinstated and fastened with the cap-screw. The base of the vise-like arrangement is made so as to connect with the bed of the







planer or the milling machine in the customary way. There is a handy wheel shaft fitted with an end block, as shown, so that the workman can very easily secure the pipe in place by revolving the wheel.

Then, again, it is often essential that some of the pipes and tubes be turned in the lathe. I noticed that one party undertook to turn threads in a lathe on a tube, and managed to break several cutting tools and likewise get a poorly made tube end. He failed to take the points of adjustment into consideration. The annexed cuts will assist in making the proper explanation. My friend did not have the cutting edge of the tool working on the surface, as at a Fig. 7. He had the cutting edge too far above the center. In other words, the point of cutting was too high. This is shown at *B*. The proper angle of clearance was lost in this adjustment. The work heated, due to unnecessary friction, while the extra pressure on the tool developed an unsteady movement.

Supposing that the tool were dropped to a point as in Fig. 10; then the cutting line *C* would be on the other extreme. The cutting edge is not on line with the motion of the revolving tube. In this case we get more of a scraping and filing result, than a genuine cutting off of the metal. The rake is practically eliminated, and the pressure of the tool required for cutting might result in breaking, or at least in springing, the tool shaft. In this adjustment you will find that the tool point will tremble, and give many indications of laboring under difficulties.

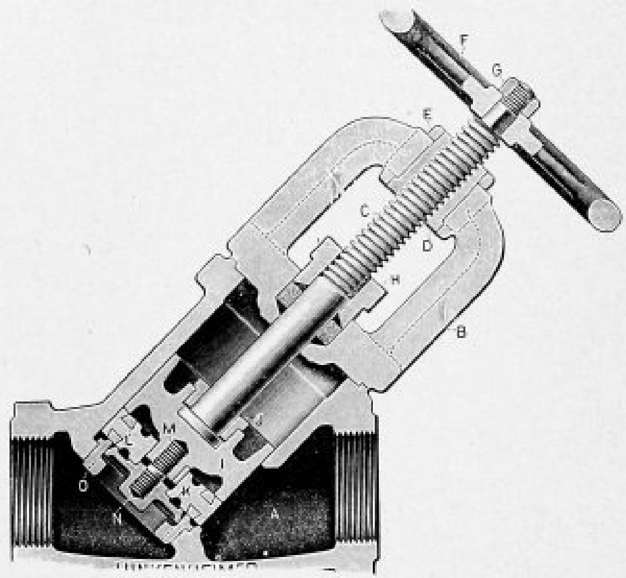
Therefore we turn to the diagram in Fig. 8, and get points on the correct adjustment of the cutting edge of the tool in order to make threads, circular keyways, and kindred work in connection with tubes and pipes of boilers. The dotted line extending from the point of cutting *A* straight down is a tangent. The line extending straight out to the left is a radial. These lines form a right angle, as can be seen. Then comes the angle of clearance, which should be about 10 degrees, and is composed of that portion of the illustration extending between the line which drops straight down from the cutting point, to a line a little to the left, running on the front of the tool. Next there is the angle of rake, which is designated between the radial line and the line running to the tool center. The angle of rake is usually about 20 degrees. The cutting angle is about 60 degrees, as a rule, but varies with circumstances.

OBSERVER.

ENGINEERING SPECIALTIES.

The Lunkenheimer Straightway Blow-off Valve.

The construction of the Lunkenheimer straightway blow-off valve is clearly shown in the sectional cut on this page. The important point in the construction of the valve is the disk *K*, which is secured to the plug *I* by means of the plate *M*, which is screwed over the stud *N*. Both sides of the disk *K* are provided with dove-tailed grooves containing Babbitt metal.



SECTIONAL VIEW OF LUNKENHEIMER STRAIGHTWAY BLOW-OFF VALVE.

Since the Babbitt metal is a much softer material than the hard bronze of which the seat is made, it is evidence that the disk will readily accommodate itself to any slight irregularity in the seat, insuring a tight joint. When the Babbitt metal on one side of the disk becomes worn, it is only necessary to reverse the disk in order to obtain an entirely new surface. When both sides become worn, either the Babbitt metal may be replaced or a new disk inserted.

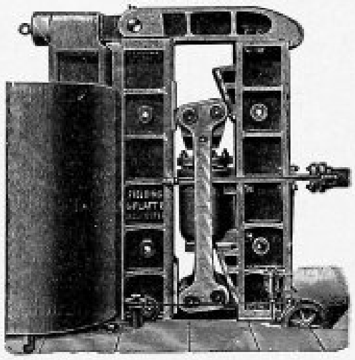
The seat of the valve is cleaned automatically whenever the valve is closed, by means of the plate *N*. When this plate enters the seat, it cuts off the scale and sediment and, as it permits only a fine spray of water to pass, any foreign matter that may have lodged on the seat is effectually removed.

The threads of the stem *C* are not in contact with the steam and, as they are always accessible for oiling, the life of the stem is prolonged. In fact, most of the features combined in this valve have been worked out with the ultimate purpose of making the valve as durable as possible.

These valves are made in two sizes—medium and heavy. The former is designed to stand a pressure of 125 pounds and the latter a pressure of 175 pounds. The Lunkenheimer Company, Cincinnati, Ohio, are the manufacturers.

A New Hydraulic Boiler Plate Bending Machine.

A machine of a new type for bending the shell plates of a boiler is being placed on the market by Fielding & Platt, Ltd., Gloucester, Eng. This machine is intended to overcome some of the disadvantages which are found in rolling plate with ordinary bending rolls. With it it is possible to bend the plate to a true curve clear to the edge of the plate, so that it is

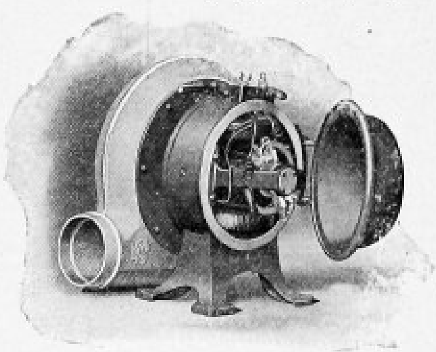


FIELDING & PLATT PLATE BENDING MACHINE.

unnecessary to shape the edges with hand hammers. In a similar manner narrow strips of plate, such as butt straps, liners, etc., can be easily and accurately bent to a true curve. It is a vertical machine and therefore occupies very little floor space, the machine capable of bending plates 1⅝ inches thick and 13 feet wide, taking up a space only 15 feet long by 5 feet 6 inches wide. It is operated with hydraulic power and is fitted with a patent automatic gear feed for feeding plates through the machine.

A Sturtevant Ventilating Set.

The motor-operated fan illustrated is placed on the market by the B. F. Sturtevant Company, Hyde Park, Mass., and is



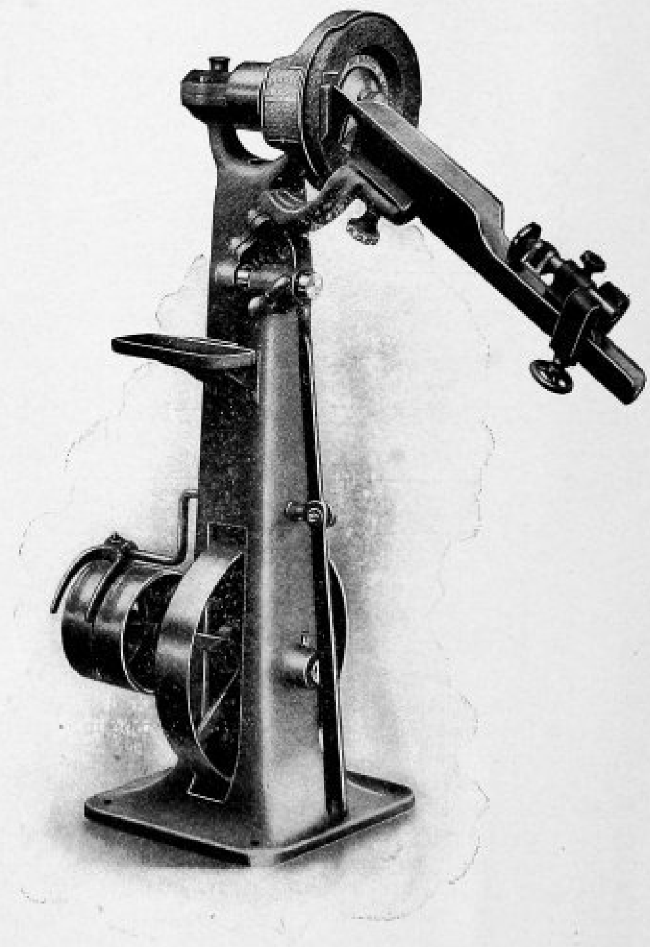
MOTOR-OPERATED FAN.

particularly fitted for marine work, as a small ventilating device. It is made in two sizes, of which the smaller consists of a No. 00 Monogram fan and a motor of one-sixth brake horsepower. This motor is series wound, and, with a nominal speed of 3,500 revolutions per minute, will force 180 cubic feet of air against a pressure of 2 ounces. The motor is furnished usually for a voltage of 220, though it can be supplied for a lower pressure. It draws power at full load to the extent of 300 watts, or about 0.4 horsepower. The entire set weighs only 75 pounds, making it easily transportable. It has the advantage of being convertible, with the discharge in any direction, while the motor can be placed on either side of the fan. The motor is placed in a dust-proof case accessible by means of a swinging door. The air outlet has a diameter of 2¾ inches.

The larger size consists of a No. 0 Monogram blower in conjunction with a one-fourth brake horsepower motor. This delivers 425 cubic feet of air per minute at 2,200 revolutions under this load, and draws 320 watts, or 0.43 horsepower.

The "New Yankee" Drill Grinder.

For accurate work, when using twist drills, it is absolutely necessary that the drill should be ground with the proper clearances and equal lips. It is a difficult job to grind a twist



THE YANKEE DRILL GRINDER.

drill properly by hand. Few, except the highest classed machinists, understand how it should be done. To meet these requirements the Wilmarth & Morman Company, Grand Rapids, Mich., have placed on the market a drill grinder with which, it is claimed, twist drills can be ground with great accuracy and with the proper clearances in a very short time. Only a simple adjustment is required to grind drills for dif-

different classes of work. The grinder shown in the illustration has a capacity for ⅛ to 2¼-inch drills, and takes up no more room than a simple emery wheel.

PERSONAL.

Mr. M. J. Guiry has taken the position of foreman boiler maker in the Great Northern shops in St. Paul, Minn.

John E. Landis, formerly of Erie, Pa., has taken the position of foreman boiler maker with the United Iron Works Company, Springfield, Mo.

Mr. R. C. Evans has been appointed superintendent motive power and car departments of the Western Maryland Railroad Company with headquarters at Union Bridge, Md., in place of Mr. William Miller, who was forced to resign on account of ill health.

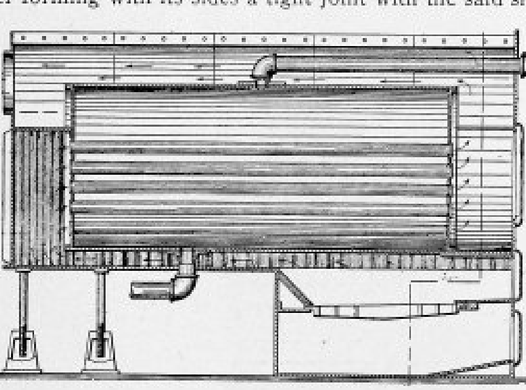
SELECTED BOILER PATENTS.

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.

862,067. COMBINATION BOILER AND FURNACE. Nathaniel Frost, of Bloomington, Ill.

Claim.—A heater, comprising a furnace casing provided on its sides with longitudinally extending shelves, a return flue boiler forming with its sides a tight joint with the said shelves,



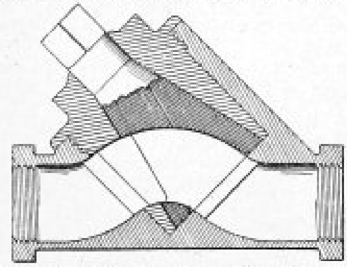
to divide the casing into an upper and lower smoke chamber, the said boiler terminating at its ends a distance from the ends of the said shell, means for supporting the boiler from the shelves, and front and rear transverse partitions, of which the front partition extends from the front lower portion of the boiler to the front of the furnace casing, and the rear partition extends from the rear end of the furnace casing to the rear end of the boiler at a point above the boiler flues. Six claims.

862,742. FURNACE GRATE. George A. Kohout, of Chicago, Ill.

Claim.—In a grate, the combination with the grate bars, of means for rocking the same, and also for shifting certain grate bars in a longitudinal direction relatively to other bars. Six claims.

862,741. BLOW-OFF VALVE. Henry Kieren, of Crystal Falls, Mich., assignor of one-half to Fred H. Miller, of Crystal Falls.

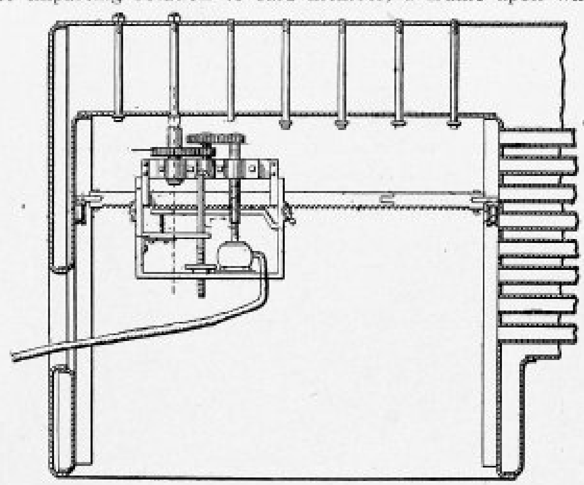
Claim.—A blow-off valve for steam boilers, consisting of a body having a reversedly curved passage lengthwise thereof and of substantially uniform diameter throughout and highest at the middle of the body and provided with a boss extending at an inclination to the longitudinal axis of the body, the body being formed with an annular seat, the lower portion of which is at the highest point of the curved passage on the lowermost side thereof and extending at an oblique angle to the longitudinal axis of the body, a shell arranged for adjustable engagement in said boss with its lower edge resting on said seat and provided with a side opening registering with the passage through the body, and a tapered plug fitting in said shell with its bottom edge designed to rest upon said annular seat within the lower edge of the shell, said plug being provided with a curved and obliquely extending opening extending from its bottom out of one side and adapted to register with the reversely curved passage in the body and with the side opening of the shell, the bottom end of said opening in the plug being



located adjacent the inner end of the passage through the body, being also of a diameter equal to the diameter of said passage and concentric to it and always open to it and in complete coincidence therewith, the said opening through the plug also being of substantially uniform diameter throughout its length, and said plug being held to its seating by pressure through the source of supply as the sole means for holding the plug to its seat. One claim.

863,074. MACHINE FOR FASTENING CROWN-STAYS IN BOILERS. Harry E. Lewis, of Columbus, Ohio.

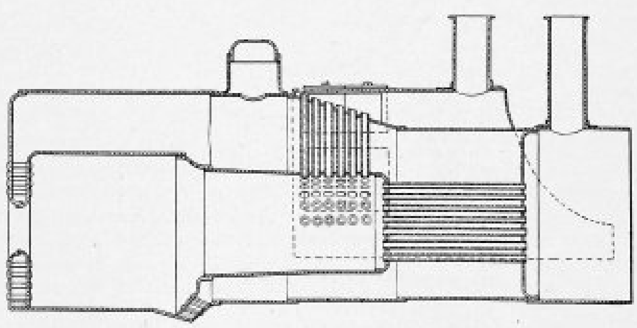
Claim.—A device including the combination with a rotative member adapted to engage the heads of crown stays, of means for imparting rotation to said member, a frame upon which



said member is mounted, and means for imparting bodily movement to said frame longitudinally of the fire-box of a boiler. Six claims.

863,931. STEAM BOILER. Joseph J. Morgan and Willard M. Hastings, of Portsmouth, Ohio.

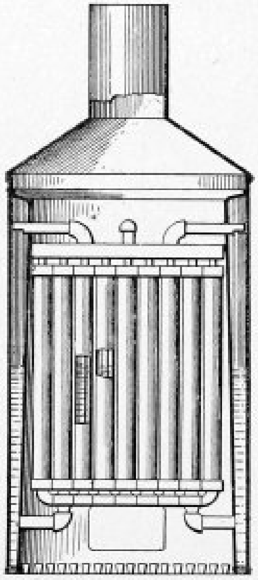
Claim.—The combination with a boiler having a fire-box therein; of a combustion compartment extending from the fire-



box and into the boiler, and flues radiating from said compartment and within the boiler. Four claims.

863,552. STEAM GENERATOR. Arnold Neuenschwander, of Louisville, Ky.

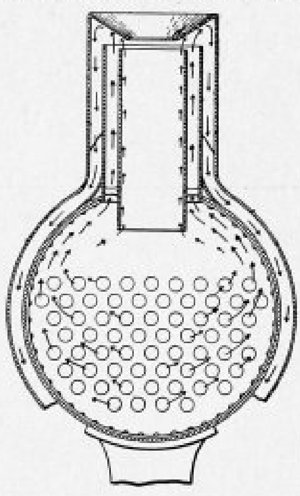
Claim.—In a steam generator, the combination of a boiler formed with a fluid containing space, a plurality of clusters of water tubes arranged within the boiler, an independent header at each end of each of the clusters of water tubes, each of said headers being provided upon one side with openings to receive the ends of the water tubes which open internally of the headers, and upon the opposite sides with openings smaller than and concentric with the before mentioned water-tube re-



ceiving openings, flues passing through the water tubes and having their ends inserted in the before mentioned openings upon the opposite sides of the headers, a nipple carried by each header, and fluid conductors connected to the nipples and establishing communication between the headers and the fluid-containing space in the boiler.

863,895. SPARK ARRESTER. Carter C. Armstrong, of Cincinnati, Ohio.

Claim.—In a spark arrester, the combination, with the smoke box, of a pair of imperforate smoke pipes, one mounted within the other, with a space between the pipes, the inner pipe provided with a free uninterrupted inlet and passage therethrough,



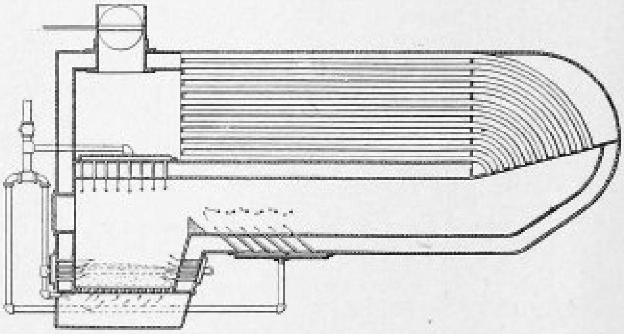
and having an extension below the inlet of the outer pipe to form a guard to direct the cinders into the outer pipe, a casing surrounding the upper portion of the pipes, with a deflecting plate extending from the casing over the opening between the pipes, and a discharge outlet from said casing. Three claims.

864,071. FURNACE GRATE. John Charles Bowring, of Sydney, New South Wales, Australia.

Claim.—An improved fire grate, comprising a plurality of parallel hollow bars parabolic in cross-section and provided with trunnions at their ends, and at their sides with narrow flanges, end bars having seats in which the trunnions rest, the bars being arranged with their flanges spaced apart from the flanges of the adjacent bars, whereby when the bars are rocked on the trunnions the flanges will move past each other to exert a cutting action on clinkers, said bars having their apexes upward and being provided with a plurality of openings in each side thereof, and at their ends, and having an arm projecting downwardly therefrom, said arm having a pintle and a drag link engaging the pintles of each of the bars. Three claims.

864,358. STEAM BOILER. Levi W. S. Busler, of Sunbury, Penn.

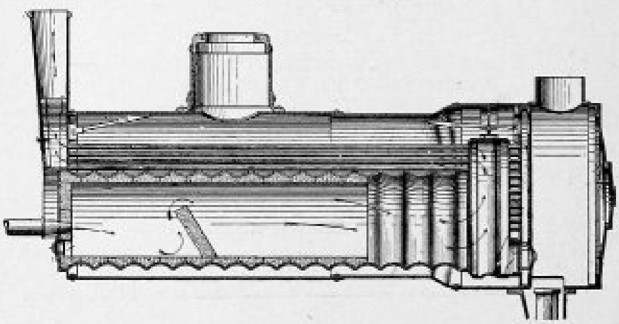
Claim.—In a steam boiler, a fire-box, and a flue each having double walls with intervening water spaces, and a crown sheet extending over said fire-box and flue, a plurality of air tubes extending horizontally through the walls of the fire-box,



a plurality of air tubes extending diagonally through the walls of the flue towards the throat between the fire-box and flue, a plurality of air tubes extending through the crown sheet over the fire-box and through a water space in the boiler, and means for conducting air to said tubes. Five claims.

864,047. LOCOMOTIVE BOILER. Herbert Jay Travis, of New York, N. Y., assignor to the Vulcan Combustion Company, of New York, a corporation of New Jersey.

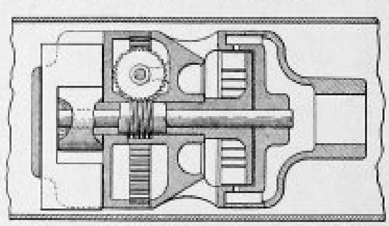
Claim.—A locomotive boiler having a fire chamber inclosed therein, means for admitting pulverized fuel through the rear end of the fire chamber, a rearwardly slanting baffle wall



extending transversely across the interior of the fire chamber and having its ends engaged in the lining of the chamber, a laterally extended chamber at the forward end of the fire chamber, return fire-tubes leading from said enlarged chamber to the rear of the boiler and an up-take in communication with the rear ends of said fire-tubes. Four claims.

864,772. STEAM BOILER TUBE OR FLUE CLEANER OR SCRAPER. Cyrus S. Dean, of Buffalo, assignor of one-half to Albert D. Jamieson, of Buffalo, N. Y.

Claim.—In a steam boiler tube or flue cleaner or scraper, the combination with a cleaner head, of a slidable cutter adapted for free vibration in both directions transversely of



the cleaner head and carrying at its opposite ends cutter blades adapted to strike from opposite sides of the cleaner head, a cam having a loose impactive co-action with the cutter for vibrating the said cutter, and means for rotating the cam. Four claims.

THE BOILER MAKER

VOL. VII DECEMBER, 1907 No. 12

LAYOUT OF AN EXHAUST ELBOW.

The introduction of the steam turbine in modern power-plant construction has made it necessary to provide much larger exhaust passages from the engine to the condenser than was formerly the case with a reciprocating engine. Commercial sizes of steam pipe are not manufactured of sufficient area to be used for this purpose. So the job of building an exhaust connection between the turbine casing and the condenser has passed from the hands of the pipe smith and steam fitter into the hands of the boiler maker. Such a connection is now made of steel plates of sufficient thickness to withstand the vacuum pressure of the exhaust riveted together and calked to prevent leakage. The illustration on this page shows such a connection recently built at the Newburgh Steam Boiler Works, Newburgh, N. Y., by P. Delaney & Company. It is 8 feet 10⅝ inches long over all, 36 inches in diameter at one end and rectangular at the other end, the opening being 8 feet 6 inches long by 12⅞ inches wide, while the distance between the center lines of the two ends is 32⅜ inches.

FIG. 1.—EXHAUST ELBOW RIVETED UP AND READY TO SHIP.

Fig. 2 shows the blue print of this connection as it comes from the draughtsman to the laying-out bench. Only the general shape and dimensions of the elbow are given, and it is left to the layer out to build it in any way he thinks best, so long as it conforms to these general dimensions. He must decide the size of the sections into which the connection shall be divided according to the size of plates he can handle most conveniently, using as large plates as possible in order to reduce the number of riveted joints to a minimum. Where the plates are very irregular in shape, with outlines which are reversed curves, it is frequently desirable to make the sections of small plates in order to avoid waste in cutting the material. Each end of the connection is to fit into a cast-iron flange in which cored holes have been provided for ⅞-inch rivets. The elbow is to be made of 7/16-inch steel plate, therefore for steam-tight work the layer out will use ⅞-inch rivets, spaced 2⅛ inches between centers with a lap of 1⅜ inches. Since the difference between the pressure of the atmosphere outside the connection and the exhaust steam inside is less than 14.7 pounds per square inch, the connection will be sufficiently strong if single-riveted seams are used throughout. It will be noted from the side elevation, Fig. 2, that while the distance between the center lines of the two ends of the connection is 32⅜ inches, the center of the lower end of the circular section is 3 inches below the center of the rectangular end. This is necessary in order to bring the connection around the 13-inch pipe shown dotted.

Since the connection is to form a reverse curve, the easiest method of laying it out, which immediately suggests itself, is to divide the connection into sections which form a regular elbow. To do this, lay down the side view of the connection as shown by the dotted lines (Fig. 3). Then from the centers *a* and *b*, divide the two curved portions of the connection into equal sections of regular elbows. It will be found that it is impossible to make these two sections meet in a smooth joint, and therefore a connecting piece, shown as section *D*, must be inserted, which has an irregular shape and must be laid out by triangulation. The part of the connection joining the last regular elbow section *G* to the rectangular flanged casting will consist of four irregular shaped plates, which must also be laid out by triangulation.

Since the sections *A*, *B* and *C* form a three-piece regular elbow, the layout of these sections is easily accomplished by dividing the base of the section *A*, a half view of which is shown dotted at the end of the section, into any number of equal parts and extending these lines to the lines of intersection between the sections. Then by drawing the center lines of the various sections and extending them beyond the elbow, the pattern for each section may be laid out directly by projecting the points of intersection between these dotted lines and the ends of the section to the corresponding parallel lines laid out in the pattern. A half pattern of each section is shown in each case. Referring to the photograph of the finished section (Fig. 1), it will be seen that section *A* is an inside section; section *B* an outside piece, etc. Thus the length of the center lines of the three patterns must be made such that when the sections are rolled to shape, section *A* must be small enough to fit inside section *B*. Since the mean diameter of the elbow is 36 inches, and the thickness of plate 7/16 inch, the length of the plate *A* will be the circumference of a circle 36 7/16 inches in diameter, or 111.72 inches. The length of the half pattern, or one-half of 111.72 inches, is indicated on the sketch. The length of section *B* will be the circumference of a circle 36 + 7/16 inches in diameter, or 114.47. One-half of this is 57¼ inches as indicated on the half pattern. The length of section *C* should be the same as that of section *A*.

Sections *E*, *F* and *G* also form a regular elbow and are laid out in the same way as sections *A*, *B* and *C*. Care should be taken in this instance, however, to divide a section of the pipe along the center line of section *G* into the required number of equal parts, and not a section taken along the edge of section *G*, as was the case with section *A*. Half patterns are shown for these sections as before, and the proper lengths for the plates are indicated on them. These patterns, of course, show the layout of the plate to the center line of the rivets. The lap of 1⅜ inches must be added outside of this, and each section should be laid out so that the longitudinal seam comes on the side of the elbow and not on the top or bottom.

Section *D* must be laid out by triangulation since it is an irregular section. The details of this work are shown in Fig 4, the horizontal line 1-9 of the side elevation is made equal to the length of *c d* (Fig. 3). The outline of the rest of the section is then drawn in, giving 1, 18, 10, 9 as the side elevation. Before constructing the plan view it should be noted that the lines *c d* and *e f* (Fig. 3) are not equal in length to the diameter of the elbow, 36 inches, and that a section of the elbow through these lines is not a true circle since the sections are inclined at an angle with the axis of the pipe. Therefore in constructing the plan view (Fig. 4), lay out the line 1-9 as stated and divide it into the same divisions as indicated on the line *c d* (Fig. 3). From these points lay off the width of the section as measured on corresponding points of the semicircle shown dotted on one side of section *G* (Fig. 3). In the same manner on the line 18-10, lay off the divisions indicated by the intersection of the dotted lines with *e f* (Fig. 3). Draw lines at right angles to 18-10 at these points and lay off the off-sets measured from the corresponding lines in the semicircle shown dotted at the left of section *A* (Fig. 3). Project the points 10, 11, 12, 13, etc., from the elevation (Fig. 4) to the plan, and lay off the corresponding off-sets at points 11, 12, 13, etc., in the plan.

Having constructed the half plan and elevation of section *D*, divide the surface into triangles as shown. Find the true length of the lines which form these triangles by constructing right-angle triangles, the height of which is taken as the

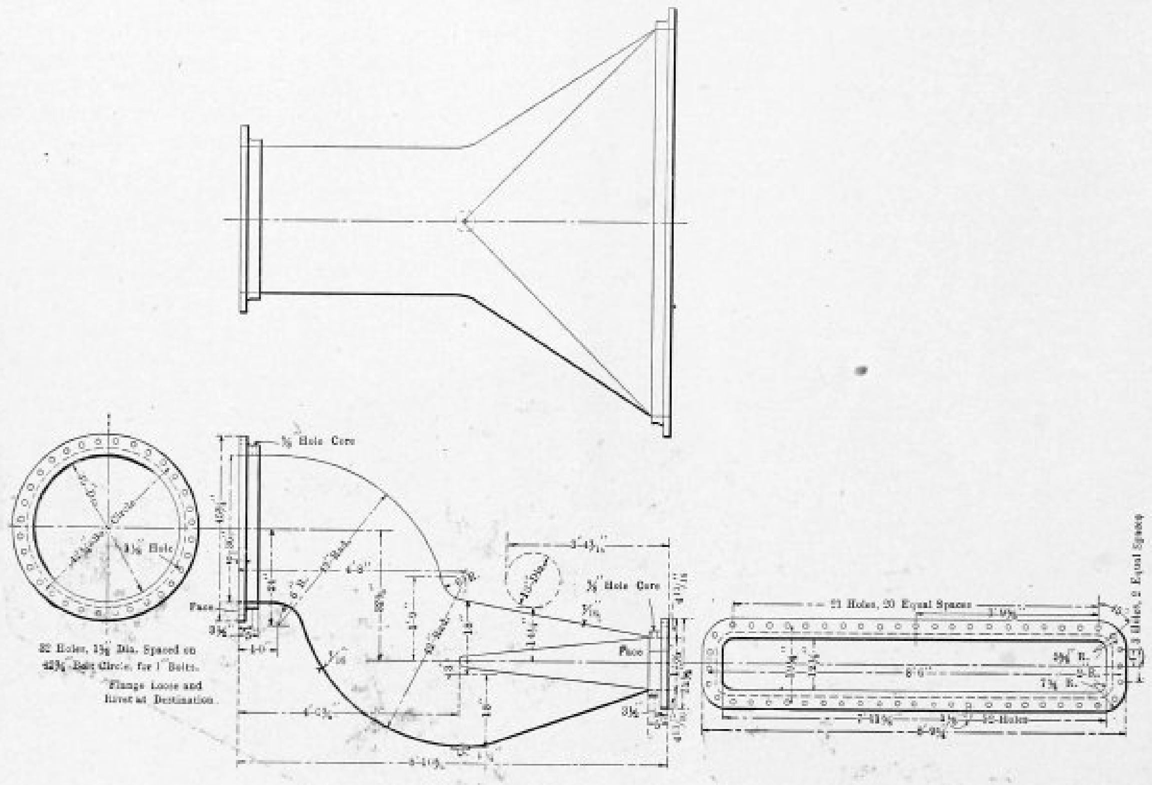


FIG. 2.—BLUE PRINT AS SENT FROM DRAUGHTING ROOM TO LAYING-OUT BENCH.

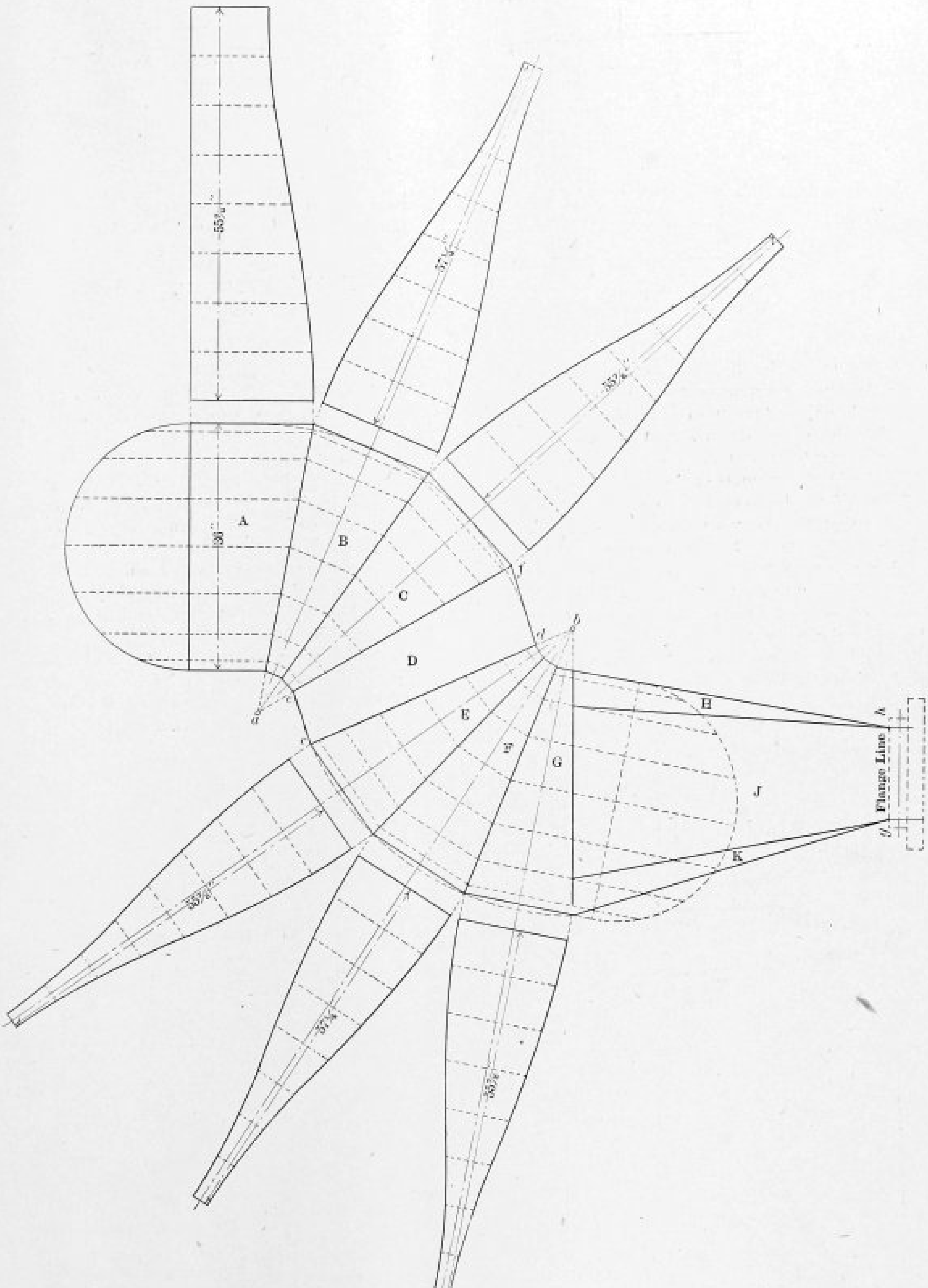


FIG. 3.—DIVISION OF ELBOW INTO SECTIONS AND DEVELOPMENT OF HALF-PATTERNS FOR REGULAR SECTIONS.

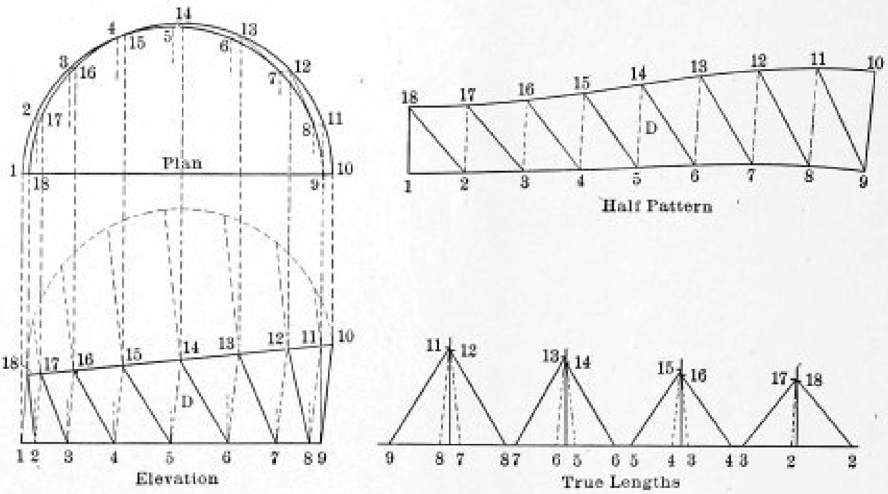


FIG. 4.—LAYOUT OF SECTION D.

height of the lines in the elevation, and the base the horizontal length of the lines as measured from the plan. The hypothenuse or third side of these triangles is the true length of the lines as they should be laid down in the pattern. This work may be easily followed through, since all lines and points are numbered similarly throughout the work shown in Fig 4. The true length of the lines 1-18 and 10-9 is shown at once on the side elevation. Therefore, when laying out the pattern, first lay down the line 1-18. Set the dividers to the distance 1-2 in the plan, and with 1 as a center, strike an arc through point 2. Set the dividers to the true length of the line 18-2, and with 18 as a center, strike an arc intersecting the one previously drawn at the point 2. Proceed in similar manner to complete the half pattern. This locates the lines through the centers of the rivets, and of course the laps should be added outside this.

Since this is an outside section, the allowance to be made in the length of the plate so that it will fit outside sections *C* and *E* should be made by laying down lines 1-9, 18-10, each 7/16 inch longer than the corresponding lines *c d* and *e f* in Fig. 3.

To obtain the layout of plates *H*, *I* and *J*, which form the connection from the round section of the pipe to the rectangular flanged casting, draw a half plan and elevation of this part of the elbow, as shown in Fig. 5. This section is to be made of four plates, two of which are of exactly the same shape, therefore only three patterns need be laid out.

Divide the semi-circle which represents the half plan of the round section of pipe into twelve equal parts. Draw lines from points 14 and 21, which locate the ends of the straight section on the rectangular cast-iron flange, to the points 10 and 4. These represent the center lines of the rivets for the seams between the side and end plates. Also draw lines from the point 14 to the points 12 and 11 and from 21 to 2 and 3. Divide the quarter circle in the corners of the rectangular casting each into three equal parts. From these points of division draw lines to the point 7. The entire surface of the half section is now divided into triangles, and it is only necessary to find the true length of these lines in order to lay out the pattern. The line 18-22 in the elevation of this section represents the flange line or the line at the top of the flanged

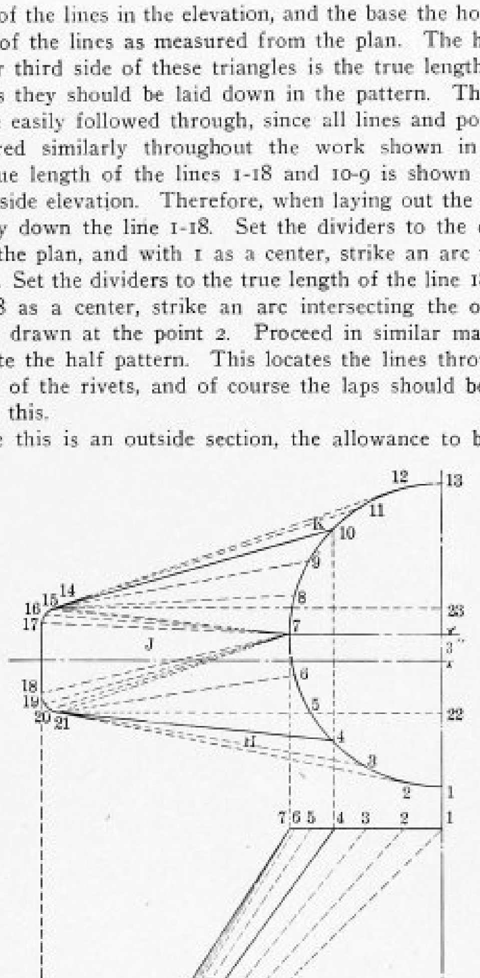


FIG. 5.—TRIANGULATION OF SECTIONS H, J AND K.

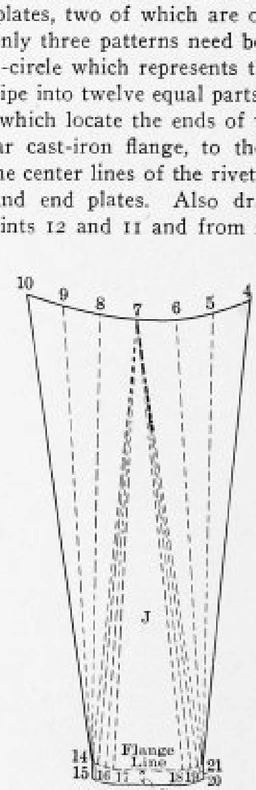


FIG. 6.—PATTERN FOR SECTION J.

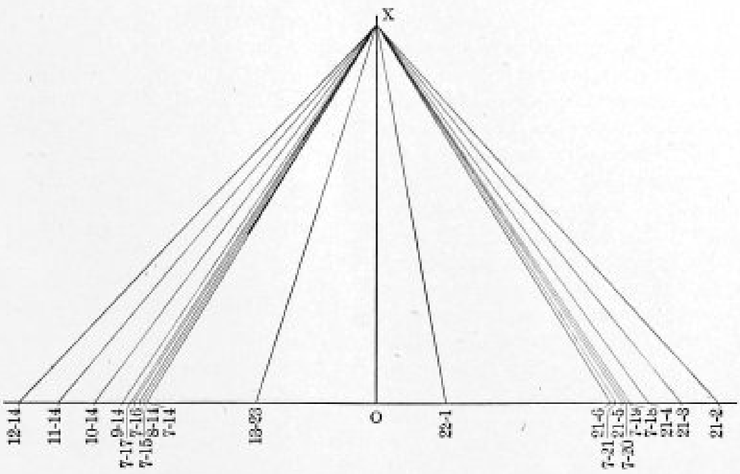


FIG. 7.—TRUE LENGTH OF DOTTED LINES IN FIG. 5.

casting marked *g h* in Fig. 3. As the patterns are laid out from this line the required depth of flange must be added so that the plates will fit into the cast-iron ring.

It should be noted that the height of all lines of which the true length must be found is the same. Therefore, lay off this height, which is equal to 1-22, at *o x* (Fig. 7). Then on either side of *o* on a line at right angles to *o x*, lay off the horizontal lengths of all the dotted lines shown in the plan (Fig. 5). Connect these points with *x*, and the resulting lines are the true lengths, which are to be used in laying out the patterns of these plates. Each of these lines is carefully marked with the numbers corresponding with the position of the line in Fig. 5.

The pattern for plate *H* is shown in Fig. 8. The flange line 21-22 is laid off equal in length to the flange line 21-22 Fig. 5. 1-22 is laid off at right angles to this, equal in length to the line 1-22, Fig. 7. Then with the dividers set to the equal spaces 1-2, 2-3, 3-4, shown in the plan view of the semi-circle (Fig. 5) strike an arc from the point 1 (Fig. 8) as a center. Set the trammels to the line 21-2 (Fig. 7), and with 21 (Fig. 8) as a center strike an arc, cutting the one previously drawn and locating the point 2. In the same manner locate points 3 and

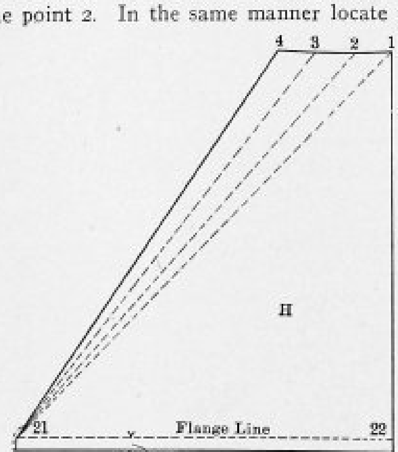


FIG. 8.—HALF PATTERN OF SECTION H.

4, which complete the outline of the half pattern of the plate with the exception of the flange below the line 21-22.

The depth of this flange may be found by first referring to Fig. 2, where it will be noted the center of the rivet hole in the flange is 1½ inches from the top of the flange. Since, however, this section is riveted to the front or longest side of the casting, the plate need be flanged only to a small angle.

Furthermore, the direction of this flange is such that the outside of the plate or the side upon which the pattern should be laid down is bent up in a reverse direction, so that the fiber on this side of the plate will be slightly shortened in the process of flanging. For this reason the depth of flange from the flange line to the rivet line may be laid off slightly less than the measured distance, 1½ inches. This allowance should be 1/16, or perhaps 3/32, of an inch, making the depth of the flange from flange line to rivet line 1 7/16 inches. At the corners of the plate, as at point 21, a little extra material should be left when shearing the plate, as indicated by the dotted line, in

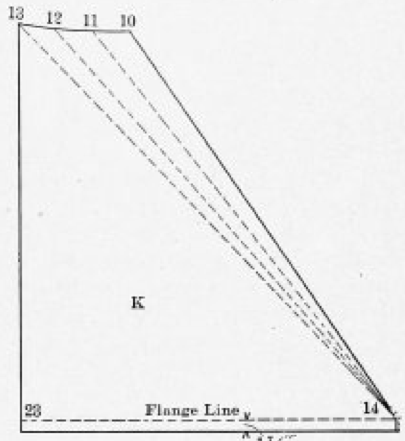


FIG. 9.—HALF PATTERN OF SECTION K.

order to compensate for the material which is drawn in in the process of flanging. After these allowances have been made the plate should fit accurately in place.

The layout of plate *K* is similar to the layout of plate *H*, except that the length of the lines is different, since the center lines of the top of the upper and lower bases of this section are 3 inches apart. The same allowances should be made for the flange as in section *H*. The pattern is shown in detail in Fig. 9.

In the layout of plate *J*, or the end of the section, as shown in Fig. 6, the flange line 17-18 is laid down equal in length to 17-18 in the plan (Fig. 5). With the trammels set to the line 18-7 (Fig. 7), and with 18 (Fig. 6) as a center, strike an arc. Reset the trammels to the length of the line 17-7 (Fig. 7), and with 17 (Fig. 6) as a center strike another arc intersecting the one previously drawn locating the point 7. Since the corners of the flanged casting are circular, with an appreciable radius, in order to make an accurate job, the portion of the flange line included between the points 14-17 and 18-21 should be located by triangulation in the same way as the upper edge of the pattern. The triangles which were used in accomplishing this are clearly numbered, and corresponding lines in Figs. 5, 6 and 7 may be easily found and the work followed through. Since this section is to be riveted to the end of the flanged casting, the angle which it makes with the flange of the casting will be large, and since the plate should be flanged downward from the side on which it is laid out, it will be necessary to add an allowance for this flanging to the distance between the flange line and rivet line as measured from Fig. 3. In this case this allowance should be aproximately ¼ of an inch, making the total distance between the flange line and rivet line 1¾ inches. The corners of the flange should be sheared, as shown by the dotted lines, to allow for the stretching of the metal when it is flanged.

Lap Joints.

W. E. O'CONNOR.

Lap joints on logitudinal seams for shells are out of date, so they say, yet a little literature on the subject may be of interest to some of the many readers of the BOILER MAKER. Fig. 1 represents a plate ¼ inch thick and large enough when laid out to roll up 48 inches inside diameter. The stamp on the plate shows the tensile strength to be 55,000 pounds per square inch. We will figure on iron rivets to shear at 42,000 pounds per square inch. In proportioning the joints for shells since the girth seams must withstand one-half as great a force as the longitudinal seams, it is necessary to design only the longitudinal seams for the greatest possible strength of rivet and plate section.

When a boy the writer was engaged to look after the heating of rivets. The commercial size of rivets in those days increased or decreased by eighths. This has since been changed to sixteenths, an arrangement which affords an opportunity for a more equal adjustment between the strength of the rivets and the plate. The Hartford Steam Boiler Inspection and Insurance Company allows for a plate ¼ inch thick the following size rivets, ½ inch, ⅝ inch, 11/16 inch. The corresponding efficiencies for a single riveted joint with rivets shearing at 38,000 pounds and the tensile strength of the plate 60,000 pounds are 50, 57 and 60 percent. Thus the larger of these rivets gives the greatest strength.

The maximum pitch for single riveted lap seams on marine boilers consistent with steam tight joints is $1.31 \times T + 1\frac{5}{8}$ where T = thickness of plate. A rule for obtaining the diameter of rivet holes for steel plates taken from W. S. Hutton's Manual on Steam Boiler Construction, page 222, is $D = T \times \frac{1}{2} + .45$ where D = diameter of rivet hole, T = thickness of plate. Substituting figures we have $.25 \times \frac{1}{2} + .45 = .575$, or say 9/16 inch diameter of rivet hole. Thurston's Manual on Steam Boilers, page 120, has this to say, "very thin plates cannot be well calked and thick plates cannot be safely riveted." The hydraulic riveter overcomes the latter, and close spacing of rivets, snugly fitting plates and true holes overcomes the former. The U. S. government rules for determining the pitch of rivets for the different grades of plates as prescribed by the board of supervising inspectors are for iron plates and iron rivets

$$P = \frac{D^2 \times .7854 \times 1}{T} + D$$

Where
P = Pitch of rivets,
D = Diameter of hole and driven rivet,
T = Thickness of plate,
For steel plates and steel rivets:

$$P = \frac{23 \times D^2 \times .7854 \times 1}{28 \times T} + D$$

To obtain equality of strength for rivets and net section of plate divide the shearing strength of one rivet (for a single seam) by the tensile strength of the plate. To the quotient, add the diameter of the rivet hole which sum will be the pitch of rivets.

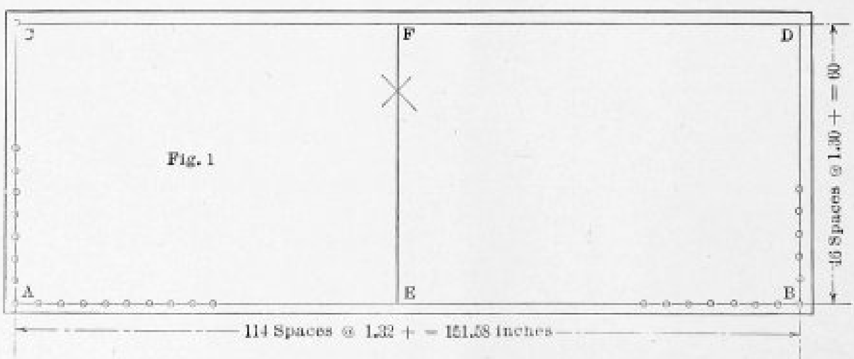
$$P = \frac{D^2 \times .7854 \times S \times N}{T \times T\ S} + D$$

Where
P = Pitch of rivets,
D = Diameter of the hole and driven rivet,
S = Shearing strength of rivet per square inch,
N = Number of rows of rivets (in this case one),
T = Thickness of plate,
$T\ S$ = Tensile strength of plate.

Substituting figures we have $.5625 \times .5625 \times .7854 \times 42{,}000 \div 25 \times 55{,}000 = .759 + .5625 = 1.321$ pitch of rivets.

The amount of lap from the edge of plate to the center of rivet hole is generally taken as one and one half times the diameter of the hole. This does not apply to seams in fire boxes when the load is compression. Here a narrower lap will obviate the sheets cracking from the rivet holes to the calking edge; $1\frac{1}{2} \times .5625 = \frac{3}{2} \times .5625 = \frac{1.6875}{2} = .843$ or say 7/8 inch lap.

Having ascertained the lap, pitch, etc., proceed to layout the plate. Commence by drawing the line AB at a distance of 7/8 inch from the edge of the plate, if the plate is beveled for calking; if not, allow for what you take off. As previously stated the plate is to roll up 48 inches inside diameter. The length corresponding to this is 48 plus one thickness of plate (¼ inch)



LAYOUT OF PLATE FOR LAP-JOINT SHELL 48 INCHES INSIDE DIAMETER.

times 3.1416 = 151.58 inches. If 48 were to be the outside diameter, substract one thickness of plate and multiply as above. Take a green switch and note the action of the bark at the inner and outer sides as you bend the switch. This is why we take the center of the material for our diameter in getting the circumference.

Lay off on *A B*, 151.58 inches, parallel to *A B*, and at a distance of 60 inches draw the line *C D*. Bisect line *A B* with the tram points and draw the line *E F* perpendicular to *A*, *B*, then with radius *E A* and *F* as a center strike a small arc at *C*. Do the same at *D*. To these points draw the lines *A C* and *B D* and if the sheet is square the diagonal distance *C B* will equal *A D*.

With our sheet squared up and ready for spacing let us see how our spacing will come out. The width of our sheet for the longitudinal seam is 60 inches, our pitch as figured out above is 1.321 inches. Any change in this pitch will effect the strength of the joint. Here is where practical knowledge

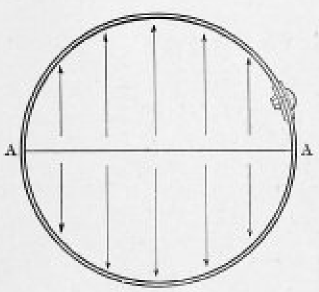


Fig. 2

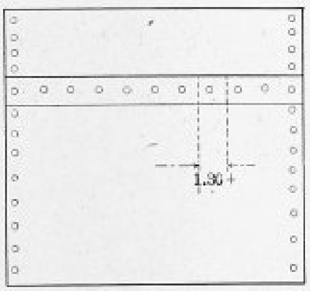


Fig. 3

LAP-JOINT SHELL AFTER ROLLING UP.

combined with theoretical knowledge is of no small importance to enable one to adjust in a correct manner any difference that may arise. To determine the number of spaces divide 60 inches, the distance of *A C*, by 1.321, the pitch, 60 ÷ 1.321 = 45 + spaces. 60 ÷ 45 = 1.33 inches pitch. As this is a little above the original pitch this would give us a stronger plate section and a weaker rivet strength. In practice it is better to have a stronger rivet section in order to assure a tight joint. Using 46 spaces, 60 ÷ 46 = 1.30 inches pitch. Step off the lines *A C* and *D B* into 46 equal spaces at 1.30 inches +. Next divide the girth seam by the pitch which is 151.58 ÷ 1.321 = 114—spaces. 151.58 ÷ 114 = 1.32 inches pitch. Step off the lines *A B* and *C D* into 114 equal spaces at 1.32 inches and the sheet is ready to punch.

In spacing up a large plate advantage may be taken of quartering the sheet. Of course in this case the number of spaces must be divisible by four.

Figs. 2 and 3 are a side and end elevation of the plate after it is rolled up.

The efficiency of the joint may be found as follows: The strength of a solid strip of plate equal in width to one pitch as shown in Fig. 2 is $P \times T \times T\,S$.

$P = 1.30$ pitch of rivets.

$T = .25$ thickness of plate,

$T\,S = 55{,}000$ pounds tensile strength of plate.

Substituting figures, we have $1.30 \times .25 \times 55{,}000 = 17{,}875$ pounds. The shearing strength of a 9/16-inch rivet is $D^2 \times .7854 \times 42{,}000 = 10{,}437$ pounds. The strength of the net section of plate is $(P-D)\ T \times T\,S$. Substituting figures we have $(1.30 - .5625) \times .25 \times 55{,}000 = 10{,}136$ pounds. It will be seen that the net section of plate is the weakest, therefore $10{,}136 \times 100 \div 17{,}875 = 56.6$ percent.

To find the allowable pressure on this shell the rule is

$$P = \frac{T \times T\,S \times E}{R \times F}$$

Where

P = Working pressure in pounds per square inch,

T = Thickness of plate,

$T\,S$ = Tensile strength of plate per square inch,

E = Efficiency of joint,

R = Internal radius,

$F = 5$ (factor of safety).

Substituting figures we have $.25 \times 55{,}000 \times .56 \div 24 \times 5 = 64$ pounds, allowable pressure with a factor of safety of 5.

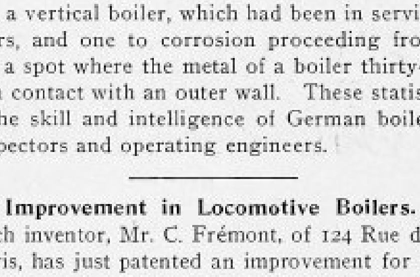
In the first part of this paper it was stated that the girth seams must withstand only one half as great a force as the longitudinal seams. Let us get the total shearing strength of all the rivets around the head, and the tensile strength of the net section of the plate, then dividing the weaker of the two by the total working pressure on the head, we will get the factor of safety. Since there are 114, 9/16 inch rivets, the shearing strength of one of which is 10,437, the total shearing strength of the rivets will be $114 \times 10{,}437 = 1{,}189{,}818$ pounds. The net section of plate is $(151 - 114 \times 9/16) \times .25 \times 55{,}000 = 1{,}202{,}850$ pounds. Therefore the rivets are the weaker. The total pressure on the head is $48 \times 48 \times .7854 \times 64 = 115{,}811$ pounds. $1{,}189{,}818 \div 115{,}811 = 13$. Thus the girth seams have a factor of safety more than twice as great as that for the longitudinal seams.

Boiler Explosions in Germany in 1906.

The statistics published by the German Imperial Statistical Office concerning boiler explosions during the year 1906 show that, exclusive of locomotives and boilers in the service of the army and navy, only fifteen explosions occurred during the year, and that only five lives were lost and three people injured by these accidents. Thirteen out of the fifteen explosions are attributed to low water; one to the failure of the bottom of a vertical boiler, which had been in service twenty-eight years, and one to corrosion proceeding from outside inward at a spot where the metal of a boiler thirty-two years old was in contact with an outer wall. These statistics speak well for the skill and intelligence of German boiler makers, boiler inspectors and operating engineers.

Improvement in Locomotive Boilers.

A French inventor, Mr. C. Frémont, of 124 Rue de Clignancourt, Paris, has just patented an improvement for locomotive boilers which is shown in the accompanying cut. As will be seen, the tube plate is connected to the cylindrical shell of the boiler by means of a flexible angle-iron, being corrugated or folded as shown. This flexible angle-iron yields under the



FLEXIBLE CONNECTION BETWEEN TUBE PLATE AND SHELL.

effect of the expansion of the tubes, and the lengthening of these is made possible by the spring action of the corrugated plate, which thus relieves the tube plate of the boiler of all unnecessary strains. The angle-iron is easily accessible, so that, if for any reason it should become cracked or damaged by the action of the expanding and contracting tubes, the damage can be immediately ascertained and the angle-iron easily (?) replaced.—*Mechanical Engineer.*

Modern Welded Pipe.*

Wrought pipe is made by the butt-weld or lap-weld process. Butt-welding consists in heating the plate in a long furnace to a welding heat throughout, and then drawing it through a bell shaped ring whereby the edges of the plate are forced together and welded. The pipe is then passed through suitable rolls, which give the correct outside diameter, and is finished by cross rolling. The latter process straightens the pipe, and at the same time gives the surface a clean finish. Leaving the cross-rolls, the pipes pass on to an inclined cooling table, up which they are rolled to the conveyors, thus preventing unequal cooling.

When cold the ends of the pipe are cut off and threaded if desired, after which the pipe is tested. A hydraulic testing machine is provided for each pair of threading machines, so arranged that the pipe can be adjusted between two water-tight heads connecting with the hydraulic line. A hydrostatic pressure of 600 pounds per square inch is applied to each piece unless a higher test is required. The pipe is then bundled and tagged, or in case of sizes 2 inches or over is stenciled with the tester's mark and the length.

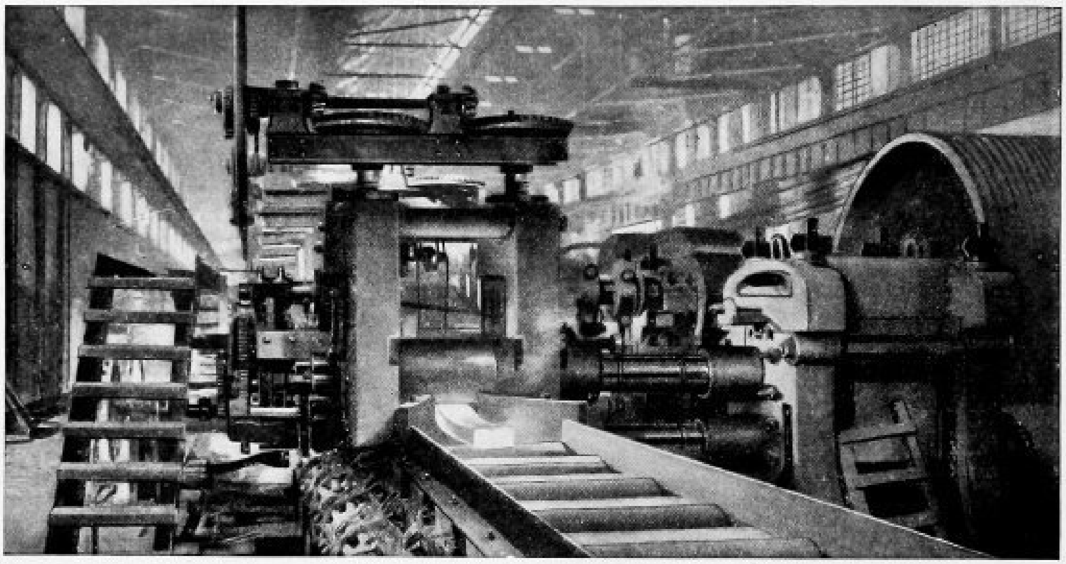


FIG. 1.—BLOOM ENTERING CONTINUOUS ROLLING MILL.

The butt-weld process has been greatly improved of late years in respect to the uniformity of the weld, due to improvements in pipe steel and the machinery in use. A number of tests have shown butt-weld steel pipe to stand from 3,000 to 6,000 pounds per square inch hydrostatic pressure, according to the size, frequently not bursting at the higher pressure.

The lap-weld process consists of two operations, bending and welding. The plate is brought to a red heat in a suitable furnace, and then passed through a set of rolls which bevel the edges, so that when overlapped and welded the seam will be neat and smooth. It then passes immediately to the bending machine, where it takes roughly the cylindrical shape of a pipe with the two edges overlapping. In this form it is again heated in another furnace similar in general construction to that used in the butt-weld department. When sufficiently heated, the skelp, as it is called, is pushed out of the opposite end to that at which it was charged, into the welding rolls. Each of these rolls has a semi-circular groove corresponding to the size of pipe being made. The arrangement of the welding rolls and machinery for operating them is illustrated by the photograph reproduced in Fig. 5. A cast iron ball, or mandrel, held in position between the welding rolls by a stout rod, serves to support the inside of the pipe as it is carried through. This "ball" is shaped like a projectile, and the pipe slides over it on being drawn through the rolls. Thus every portion of the lapped edge is subjected to a compression between the ball on the inside and the rolls on the outside, which reduces the lap to the same thickness as the rest of the pipe, and welds the overlapping portions solidly together. Following the welding rolls are the sizing rolls, straightening rolls and cooling tables. As the width of overlap of the edges is three or four times the thickness of the material, the weld is as strong as any other part of the pipe, if not stronger.

From the manufacturer's standpoint, the ideal material for making welded pipe should be uniform in quality from day to day, easy to weld and strong enough to stand the strains involved in welding. Pipe steel comes closer to this standard than wrought iron of any kind, and the cost is naturally less, as the metal is made in comparatively large quantities and in a much shorter time with a minimum of labor. Wrought iron, on the other hand, is naturally variable on account of: First, irregularity in the pig iron used; second, the small quantity made in one heat; third, the amount of personal attention and skill required of the puddler. Pipe steel, or what would be more properly termed "ingot iron," while being superior in point of uniformity of welding qualities, approaches more nearly to pure iron in composition and has greater strength and ductility, and, like good wrought iron, cannot be hardened by quenching from red heat in water.

The variation in carbon in pipe steel manufactured frequently does not exceed 1/100 percent from one year's end to the other, while on general orders the steel maker requires at least two or three times this latitude in specifications. Other deleterious elements are reduced to such a point as will not interfere with welding. The physical properties of pipe steel and wrought iron made for this purpose will average:

	Pipe Steel.	Wrought Iron Pulled Longitudinally.
Tensile strength..	58,000 lbs. per sq. in.	46,000 lbs. per sq. in.
Elastic limit......	34,000 lbs. per sq. in.	28,000 lbs. per sq. in.
Elongation........	22 percent in 8 ins.	12 percent in 8 ins.
Reduction in area.	55 percent.	25 percent.

Wrought iron will vary from 4 to 16 percent in elongation, whereas steel may be expected to range between 19 and 25 percent.

* By courtesy The National Tube Company.

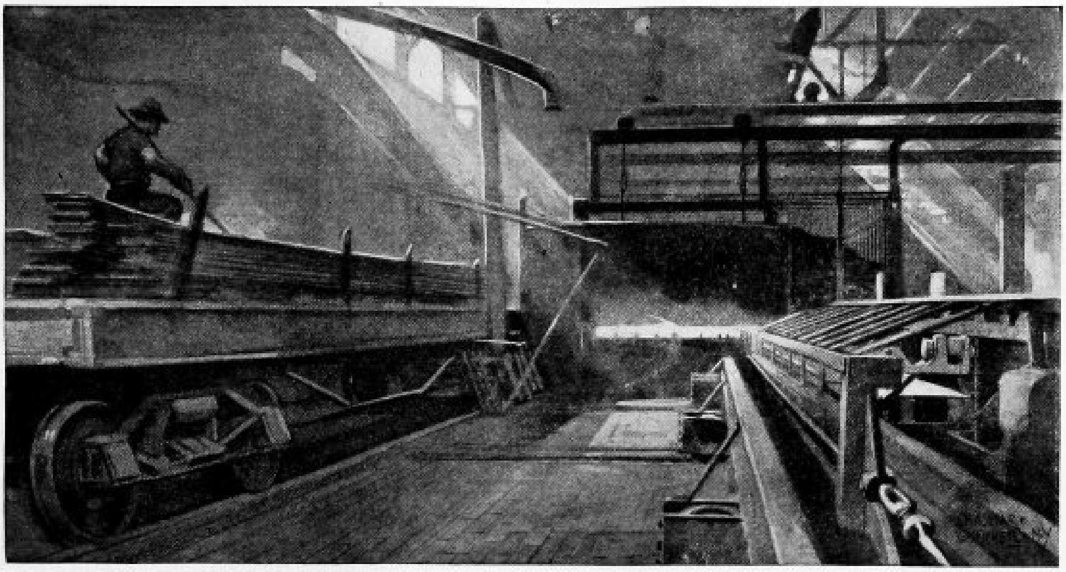


FIG. 2.—CHARGING PLATE INTO BUTT-WELD FURNACE.

Puddled iron pulled crosswise rarely gives 34,000 pounds per square inch tensile strength, and the elongation and reduction in area are proportionately low and variable.

As to the welding qualities of the two materials, pipe steel is now superior, particularly in uniformity. The tensile strength of this steel is about double that of wrought iron taken transversely, and, as might be expected, it has been shown that steel pipe butt-welded is about twice as strong in the seam compared with wrought iron.

It will now be understood why steel pipe should cost less, and why the introduction of this material has lowered the price of pipe. The competition of steel has caused some to cheapen their wrought iron by the use of a doubtful quality of steel scrap in the puddle furnace, thus reducing time and cost of puddling. The steel used for this purpose is most likely of higher carbon and wholly unsuited for the purpose, the result is a pipe hard in spots and irregularly welded. Split seams and bad welds have frequently been traced to such "iron" after the trouble had been credited to "steel." Genuine pipe steel can readily be distinguished from wrought iron, being tougher and less brittle under the hammer.

The production of wrought pipe has about doubled since 1899, and now nearly equals the tonnage of structural steel, not including plate. The fact that about 80 percent of wrought pipe is now made of steel shows with what favor this material is being received after a trial of twenty years under all manner of service.

The corrosion of tubes and pipes is a question which has been under discussion ever since steel came into serious competition with iron, and much careful work has been done to determine the relative rates of corrosion under various conditions. Air and moisture combined are essential to the ordinary rusting of iron, but sulphurous acid, electrolysis, galvanic action and other influences greatly accelerate corrosion nowadays. Practically speaking, iron will last indefinitely in dry air or in pure, air-free water. It is well known that slight changes in environment greatly effect the rate of corrosion; hence opinions founded on anything but precise

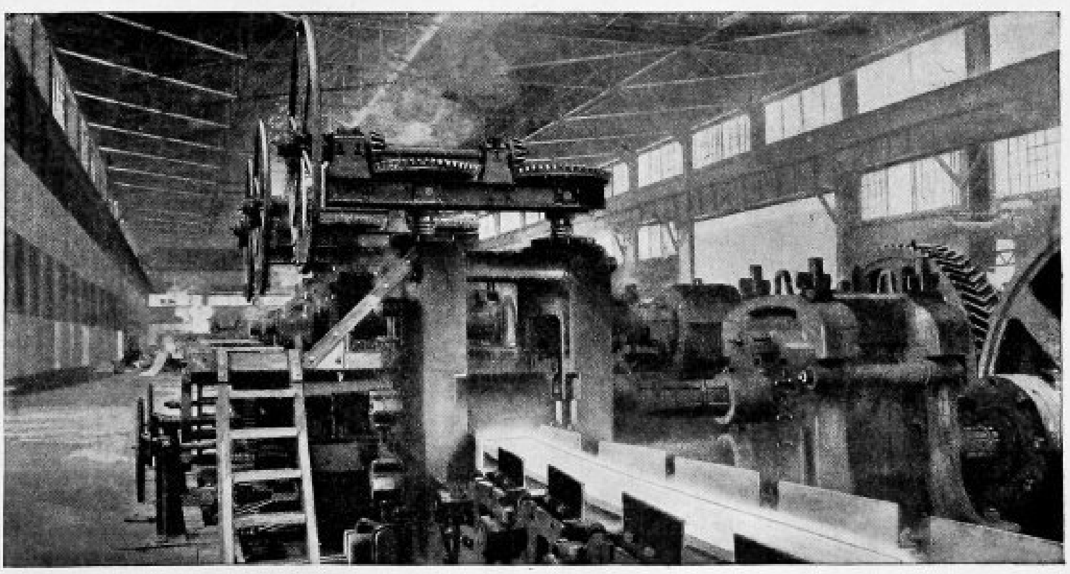


FIG. 3.—PLATE PARTLY FINISHED.

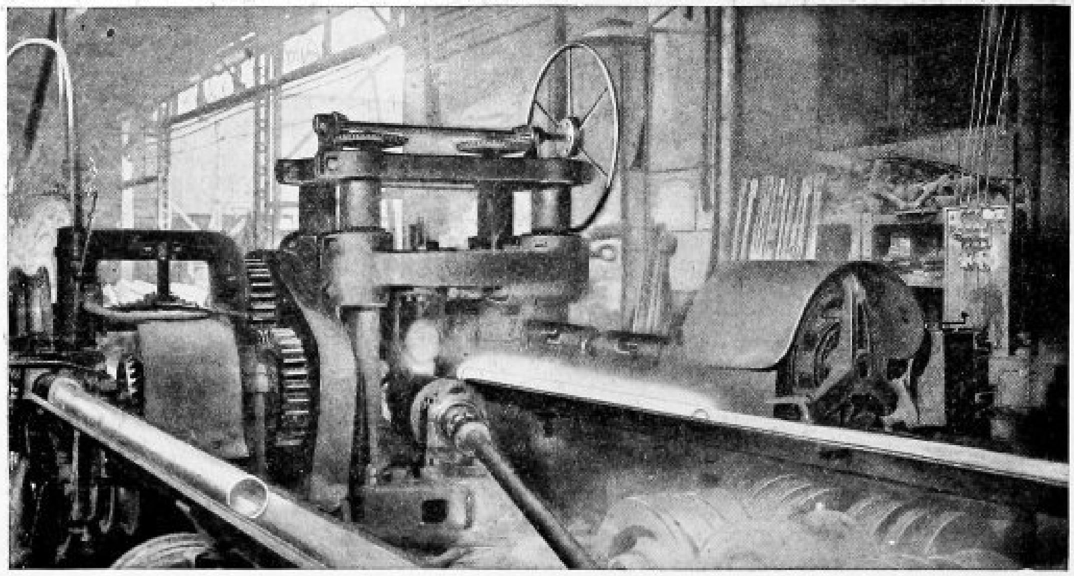


FIG. 4.—LAP-WELD BOILER TUBES PASSING THROUGH SIZING AND CROSS ROLLS.

knowledge through comparisons made at the same time, under the same conditions, are likely to be far astray from the truth, especially where records of the life of pipe under service conditions of twenty years ago are compared with that used under more active corrosive agencies of the present. The fact that steel pipe has come into wide use simultaneously with a great increase in the sulphurous acid in our city air and stray electric currents and corrosive matter in the ground, may lead the general observer to conclude that the more rapid corrosion of to-day is due to the new ma-

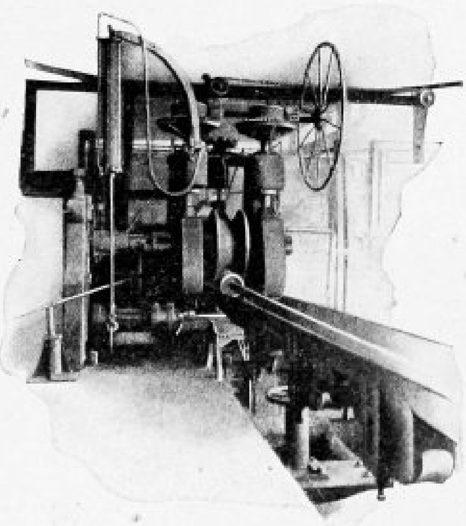


FIG. 5.—WELDING ROLLS WITH CAST IRON MANDREL IN POSITION.

terial, when in fact it may be entirely owing to the more active corrosive conditions which now prevail.

A large number of tests taken where the two materials were in use side by side or in pipe lines have demonstrated without exception so far that when the steel pits, iron is equally affected, and in some cases even more so, and it now appears that steel can be made so as to have a decided advantage over wrought iron under corrosion.

Layout of an Irregular Connection.

Pattern for a Connection from a Round to a Rectangular Opening, the Ends of which are not Parallel.

BY CHARLES P. DIVERS.

C, N, F, Y shows the front elevation of the round end, and *J, G, E, H* the front elevation of the rectangular end. The side elevation of the connection is shown at *D, M, K, I*. Using *M K* in the side elevation as a diameter, draw the semi-circle *M, L, K*, and divide it into any number of equal parts; also draw another semi-circle *A, T, Z* above the side elevation and in the relation to it shown in the illustration. Divide this semi-circle into the same number of equal spaces as the first one.

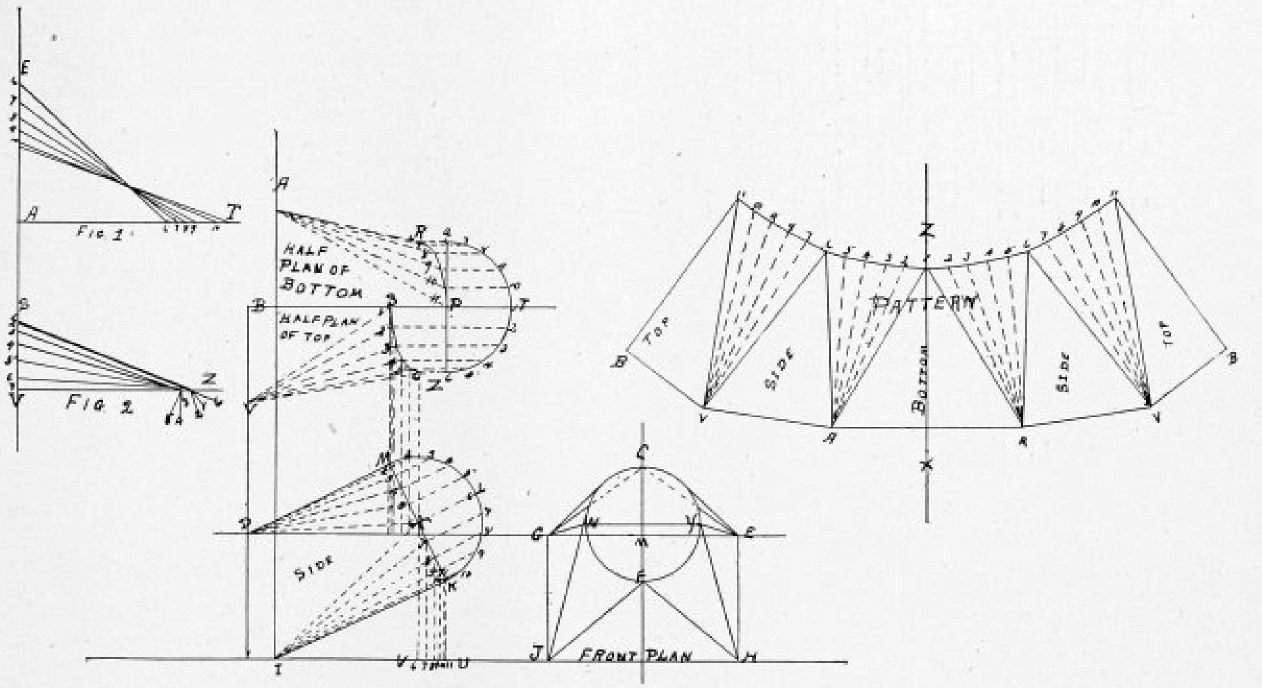
From the points of division on the semi-circle *M, L, K*, draw lines at right angles to *M, K*, intersecting it at the points 2, 3, 4, etc. Project lines from these points upward until they intersect horizontal lines drawn from corresponding points on the semi-circle *R, T, Z*. Lay off at *B A* in the half plan of the bottom one-half the distance *J H* measured from the front elevation, then draw lines from *A* to the points of intersection previously located from *R* to *P*. The solid line drawn through these points from *R* to *P* gives the true shape of one-half the bottom.

Find the half plan of the top, which is obtained in the same way as the half plan of the bottom, except that the points in the upper half of the side elevation are used instead of those on the bottom.

To construct the triangles which give the true length of the lines to be used in developing the pattern, draw the triangle *S, V, Z*, Fig. 2. Lay off on *V S* the distances *V*-7, *V*-6, *V*-5, etc., as measured from *M, W, X* in the side elevation; then lay off on the line *V Z* the distances shown by the dotted lines included in the section *S, V, Z* of the half plan of the top. Draw lines connecting the corresponding points on *V S* and *V Z* as 1-1, 2-2, 3-3, etc., which are the true lengths of the lines *D*-1, *D*-2, *D*-3, etc., in the side elevation.

In a similar manner lay out the lines *A E* and *A T* at right angles in Fig. 1, and on *A E* lay off the distances measured on the dotted lines in the side elevation, included in the Fig. *X, K, U, V*. At *A T* lay off the distances measured on the dotted lines included in the Fig. *A, R, P* in the half plan of the bottom. Draw lines connecting corresponding points on the lines A E and A T completing the triangles.

To layout the pattern, first draw the line Z X as the center line, and lay off on it the distance D M taken from the side elevation. Draw A A at right angles to Z X, making A A equal in length to G E in the front elevation. Set a pair of dividers to the length of one of the equal spaces into which the semi-circles M, L, K and R, T, Z were divided, and, with the point 1 in the pattern as a center, strike arcs on either side of the line X Z at points 2, 2. With points A in pattern as centers, and the distance 2-2 measured from Fig. 2 as a radius, strike arcs cutting those previously drawn at points 2, 2. Continue in this manner to locate the points 3, 4, 5 and 6, then, with A as center, and a radius equal to D-1 measured from the side elevation, strike an arc at point V in the pattern. With 6 as a center, and a radius equal to the distance 6-6, Fig. 1, strike an arc intersecting the one previously drawn at V. With V as a center, construct the triangles 6 V 7, 7 V 8, 8 V 9, etc., until point 11 is reached. Then with V as a center, and a radius equal to one-half J H measured from the front elevation, strike an arc at the point B. With point 11 as a center, and a radius equal to K I, measured from the side elevation, strike an arc intersecting the one previously drawn at B. Draw the lines V B and B 11, and the pattern is complete, with the exception of adding the proper allowances for laps, seams, etc., which will vary according to the thickness of the material, size of rivets, etc.



TRIANGULATION AND PATTERN OF IRREGULAR CONNECTION.

Locomotives with Superheaters on the Canadian Pacific Railway.

Superheated steam has been extensively adopted on the Canadian Pacific Railway, more than 197 locomotives now being fitted with superheaters. The more successful types have proved to be the Schmidt smoke-tube system, the Cole return-bend and the Vaughan-Horsey return-bend types. Results of tests extending for periods of about six months show that a saving of about 10 to 15 percent in freight service, and 15 to 20 percent in passenger service, over engines using saturated steam, is obtainable by the use of superheater locomotives.

New Methods of Making Boiler Repairs.*

BY HARRY RUCK-KEENE.

It is proposed in this paper to describe two processes of effecting repairs to boilers by welding in place, which have so far given satisfactory results, and at the same time have effected repairs at probably less cost and in many cases in less time than by the ordinary methods of welding. These processes are the oxy-acetylene and electric systems of welding, whereby cracks in plates may be welded up in place, patches may be fitted and welded in place without forming new seams, as would be necessary if they were riveted, and wasted plates and landing edges may be built up to their required thicknesses.

It was formerly the practice of several well-known firms when making iron boilers to weld the longitudinal seams of the shell plates instead of riveting them, and in 1874 some exhaustive tests proved the efficiency of these welded seams to be about 70 percent of the solid plate. I have heard of only one case in which the weld gave way, and that was in 1889, when a boiler, eight years old, was subjected to hydraulic test, after undergoing repairs, and the longitudinal seam cracked through the weld for a length of about 6 inches. When steel took the place of iron in the manufacture of boilers this practice of welding longitudinal seams was discontinued. But many firms still continue to weld the furnaces to the tube plates in steel boilers, and it is the universal practice nowadays to weld the longitudinal seams of furnaces, no matter whether they are of the plain, corrugated or ribbed type. So that it will be seen that welding, though decried by many engineers, is still extensively used in the manufacture of boilers.

In the oxy-acetylene and electric processes of welding, though the surfaces of the metal to be welded are heated up to practically the same temperature as in the ordinary methods of welding, yet the subsequent hammering, squeezing or rolling is dispensed with, except in that process of

* Read before members of the Institute of Marine Engineers at the Engineering and Machinery Exhibition, Olympia, London, Sept. 28, 1907.

electric welding which I propose to describe where a certain amount of hammering is still used in making the weld.

For the purpose of repairing boilers by the oxy-acetylene process the necessary apparatus consists of a steel cylinder containing oxygen gas and another containing dissolved acetylene, both under pressure, a special blow-pipe, flexible tubes for transmitting the gases from the cylinders to the blow-pipe, and small bars or rods of iron or mild steel about three-sixteenths inch diameter, which are fused and attach themselves to the parts to be united. The oxygen and acetylene gases in these cylinders are led to the blow-pipe by means of the before-mentioned pipes, and there ignited at the nozzle, the resultant flame giving out an intense heat. Where plates are wasted away by corrosion or otherwise, the wasted parts are first thoroughly cleaned to remove any dirt or grease, and are then heated to a welding heat by means of

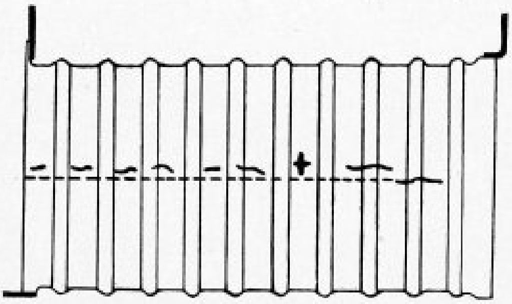


FIG. 1.

the flame from the blow-pipe; the iron or steel bar is in the meantime held in this flame until a small portion at the end of the bar is melted off and attached to the part to be repaired, and this process is continued until by the addition of drop after drop sufficient metal has been added to bring the plate up to its required thickness. When a crack in a plate has to be welded up, the metal on either side of the crack is cut away to form a V-shaped groove. This enables the flame to penetrate to the bottom of the crack and heat the surrounding metal to the required temperature, metal being at the same time added from the small bar to fill up the groove, in the same way as the wasted plate was built up. In a similar manner, by chamfering away the edges, two plates can be welded together. Naturally in all these cases great care must be taken to see that each and every piece of metal added becomes firmly attached before adding more

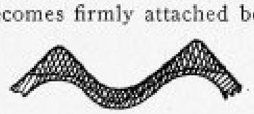


FIG. 2.

metal to it. This process has been very satisfactorily employed in this country for many purposes, and more especially for welding flanges and branches on iron and steel pipes (which have to withstand high pressure), but so far it has been little used for effecting boiler repairs. In Marseilles and Genoa, however, a number of boiler repairs have been carried out in the last few years by this process with satisfactory results.

Among other repairs I may mention those carried out on two marine boilers where the bottom plating of the combustion chambers and the lower part of the combustion chamber back plating, and also parts of the furnaces (nineteen-thirty-seconds inch thick) were considerably wasted by corrosion. The defective parts were cut out, patches made to suit, and instead of riveting them on, they were welded in place by this process, thus avoiding the making of additional riveted seams in the furnaces and combustion chambers, which often give so much trouble in boilers. The landing edges of the lower part of the back end plates of these boilers were also considerably wasted, and these were made good and built up to their original thickness in the manner I have already described. These repairs after twelve months' work were examined and found to be quite satisfactory and showed no signs of leakage.

In another case eighteen furnaces of the main boilers of a vessel were so badly wasted by corrosion on the water side near the line of firebars, that in the ordinary way these furnaces would have had to be renewed, but by this process the wasted parts of these furnaces were built up to their required thicknesses by welding on sufficient metal piece by piece, thus saving the time and expense of renewing the furnaces. In another case the furnaces of some other boilers were badly wasted and cracked, and these were satisfactorily welded up by the same process; there being in all about 100 cracks in the two furnaces, the repairs taking about three weeks. Figs. 1 and 2 illustrate the way in which such cracks and wasted portions are filled up in the case of a corrugated furnace. After the welding operation it is usually considered better to heat the surrounding plate by means of the blow-pipe flame to counteract, as far as possible, the strains that might be set up by the intense local heat. Naturally if it were possible it would be better to properly anneal the plate dealt with.

This process has also been very successfully employed in the cutting out of defective and damaged plates, the flame

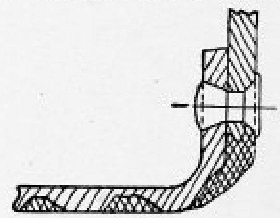


FIG. 3.

from the blow-pipe melting and thus cutting a groove about three-sixteenths inch wide, in much the same way as would be done by a band saw, the separation being quite as cleanly and accurately done and in much less time than by the ordinary methods of hand cutting. The following are results of tests made from samples taken from a plate welded by the oxy-acetylene process:

OXY-ACETYLENE WELDING.

	Breadth.	Thickness.	Area.	Tons, Total.	Tons per Sq. In.	Extension in 4 Inches Percent.
	Inches.	Inches.	Inches.			
Not annealed..	1.5	.62	.93	22.85	24.5	30 } Solid plate.
Annealed......	1.5	.62	.93	22.35	24.0	36 }
						Extension in 8 inches percent.
Not annealed..	1.5	.62	.93	22.9	24.6	28 } Broke away
Annealed......	1.5	.63	.945	22.1	23.3	29 } from the weld

COLD BENDS.

Not annealed....................................	180°
Annealed..	180°

These results show not only the efficiency of the weld, but also that the ductility of the surrounding metal in the way of the weld has not been distressed by the intense local heat. It will be noticed that the tensile strength of the welded plate is the same as that of the solid plate, the elongation percent is also the same, and the bend tests are quite as good as those which might be expected from the solid plate.

There are several systems in use for welding by electricity which have been employed for a number of years, and are used, among other things, for welding tram-rails in place, in making good blow-holes, etc., in steel castings, and also in welding together pipes, more especially those for refrigerating plants, which must withstand high pressures. As with the oxy-acetylene process, little use has so far been made of these processes in this country for repairing boilers. In the last few years, however, electric welding has been used abroad for this purpose, more especially at Gothenburg, in Sweden, where quite a number of boiler repairs have been carried out by this process. The process there employed is somewhat similar to the oxy-acetylene process, but the heat is generated by an electric arc instead of by the flame from the blow-pipe. The plant there used consists of a barge containing two dynamos of 45 kw. power, driven by a steam engine, and a third dynamo of 3 kw. power for feeding the magnets. The voltage used is between 80 and 120. There are two sets of cables leading from the dynamos, so that

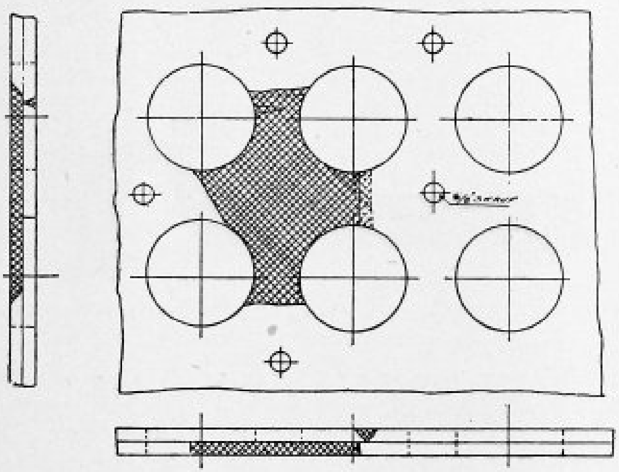


FIG. 4.

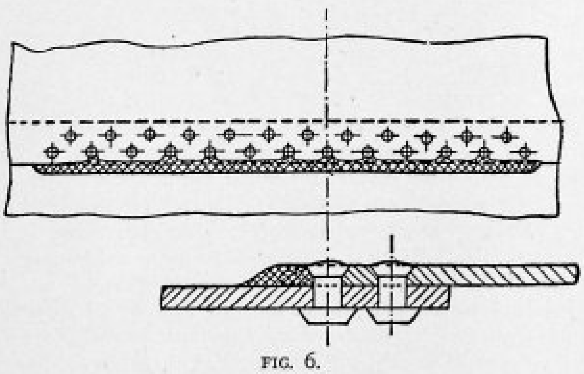


FIG. 6.

work can be carried out at two different places at the same time. The cable from one pole of the dynamo is connected to some part of the boiler and the cable from the other pole is connected to the welding bar (which consists of a bar of specially prepared steel about three-sixteenth inch diameter). This welding bar is fixed in an insulated holder, and on being brought into contact with the article to be dealt with and then withdrawn a short distance, an electric arc is formed, which rapidly heats the parts in close proximity to the arc, and at the same time the end of the bar is heated to almost a molten condition; this is then pressed against the parts to be welded, and since they are now heated to a welding temperature, a small portion of the end of the bar attaches itself to them, in a similar manner as an almost melted piece of sealing wax is made to adhere to paper; after this small portion of nearly melted metal is attached, the bar is withdrawn, thus breaking off the electric current. The added metal is then hammered to insure its being thoroughly united with the parts to be welded. The welding bar is then again brought into contact with the parts being dealt with, withdrawn a short distance to again form an electric arc, and the surface of the metal and also the previously welded metal, are again heated to a welding temperature and another small portion from the end of the bar is added and hammered as before. Thus the cycle of operations continues until sufficient metal is added for the opening between the two pieces of metal to be entirely filled up, in the case of welding two plates together, or the wasted portions of a plate have been brought up to the required thickness.

The following are the results of tests made in June last from a plate welded by this process:

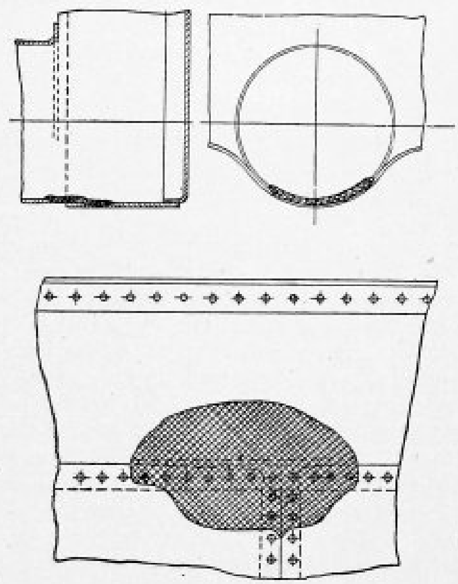


FIG. 5.

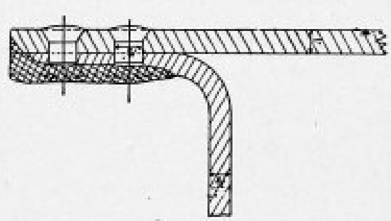


FIG. 7.

ELECTRIC WELDING.

	Breadth.	Thickness.	Area.	Tons, Total.	Tons per Sq. In.	Extension in 4 Inches Percent.
	Inches.	Inches.	Inches.			
Not annealed..	1.0	.56	.56	15.35	27.4	12 Broke
Annealed......	1.0	.55	.55	14.5	26.3	14 through weld

COLD BENDS.

Not annealed..	58°	Showed signs of fracture at weld.
Annealed........	160°	

It will be seen that after annealing much better results were obtained than before annealing. But unfortunately one cannot anneal a boiler in place.

Any number of illustrations might be given showing repairs made by this process. In Fig. 4 the tube plate shown was laminated. The greater part of the lamination was cut away, and the plate built up to its required thickness, as shown. The small screw pins were put in as a safeguard to avoid any opening up of the lamination in case it developed beyond its known extent. In Fig. 5 a portion of the lower front plate of a marine boiler was wasted away, including several rivets. Repairs were made so that the rivets were welded in to form an integral part of the plate. Fig. 6 shows a similar piece of work on the seam of a stationary boiler. The defective parts shown in Fig. 7 are about 3 feet in length, and are the result of wasting and pitting by corrosion on the combustion chamber plating and tube plate of a marine boiler. The illustration shows how the repairs were made.

Pneumatic Tools for Boiler Shops—II.

Important Points on the Design, Operation and Care of Pneumatic Drills, Hammers and Hoists which are Used in Boiler Shops.

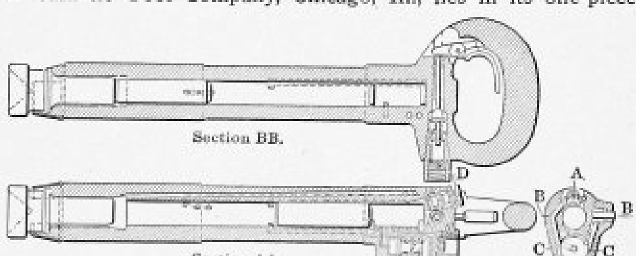
BY CHARLES DOUGHERTY.

Riveting Hammers.

While much can be said on the subject of pneumatic drills, the subject of pneumatic hammers is infinitely larger, inasmuch as there are several companies which manufacture hammers exclusively. A prominent user once said, "I care not who makes the contracts, give me a good pneumatic hammer and I will fill them." We do not know whether this user had any particular type of pneumatic hammer in mind when he made this statement, but it is evident that from the various types herein described, it would be a very hard matter to adopt any particular type, judging from a standard of the amount of work possible to be derived from any of them. In this respect the prominent makes differ but very little, but each of the makers, knowing that it is useless for the capacity of a tool to exceed the limit of endurance of the operator, strives to perfect his tool in such a manner as will increase its longevity. This goal, for which all the makers strive, has resulted in bringing forth many novel and useful features, among which may be mentioned auxiliary valves, hardened and ground valves, made "fool" proof and sealed; valves worked by differential areas, valves operated by differential pressures, hardened and ground cylinders, direct-acting throttle valves, balanced throttle valves and numerous other useful and beneficial features.

THOR HAMMERS.

The main novelty and greatest advantage of the "Thor" long-stroke riveting hammer, manufactured by the Independent Pneumatic Tool Company, Chicago, Ill., lies in its one-piece



SECTIONS OF THOR ONE-PIECE RIVETING HAMMER.

construction. The handle, barrel and valve block are all one solid piece of steel forging. All other makes of riveting hammers are made in three main parts—barrel, valve block and handle—a construction which requires the use of couplings, clamps, keys, lock nuts and other complicated mechanism, which frequently become loose and cause considerable delay, annoyance and expense by the necessity of having them tightened.

The main valve of the "Thor" long-stroke hammer lies parallel with the main bore, but it is not directly operated with the air in the downward stroke. When the piston returns it opens what is termed the auxiliary valve, the office of which is to admit a slight amount of air, which starts the piston downward gently, and also helps to supply air for the power stroke. After a short travel in the downward direction, the main valve opens and admits a great volume of air direct and very close to the piston. This hammer, therefore, from a gentle start gets an extremely forceful and quick acting blow and quicker return with very little vibration. On account of its one-piece construction the hammer is obviously lighter than any other make, and there are few parts that can possibly work loose from vibration. While the one-piece construction has its good points, some users object to such construction on account of the danger of breakage, which, of course, results in the necessity of purchasing an entirely new hammer, with the possible exception of the valve and piston.

Another feature of this hammer is the inside safety trigger. The trigger is entirely protected by the handle and hammer itself, and when not in use will fall away from the handle by

SHORTNESS OF OVER-ALL LENGTH AND UNIQUE LOCKING DEVICE ARE CHARACTERISTICS OF THE BOYER RIVETER.

its own weight. Since when the hammer is picked up the workman has his fingers between the hammer handle and the trigger, it can never be discharged in carrying or in waiting for a rivet. As the trigger is short it is not necessary to release the entire grip of the handle when again getting in position to operate the hammer. Another point gained in this construction is that the outside of the handle is perfectly smooth, therefore the workman has a large area of smooth surface on which to exert a pressure on the handle in riveting.

"BOYER" RIVETER.

The "Boyer" riveting hammer, manufactured by the Chicago Pneumatic Tool Company, Chicago, Ill., was one of the first tools placed on the market for doing pneumatic riveting. Its popularity was due not so much to its lack of competitors as to its design, which included many desirable features. In general outline it can be distinguished from other types by reason of the hexagonal portion on the cylinder, its shortness of over-all length, and the method of locking the handle in the cylinder. Perhaps the most important of these features is its shortness of over-all length, which makes the tool especially adaptable for work in short space. This is a result of the construction of the valve, which is distinct from all other types, and is so constructed that the piston may pass entirely through it. It will, of course, be readily seen that from such a construction a hammer of this type can be made 1 or 2 inches shorter in over-all length, and yet maintain the length of piston stroke obtained in hammers of other types of the same capacity.

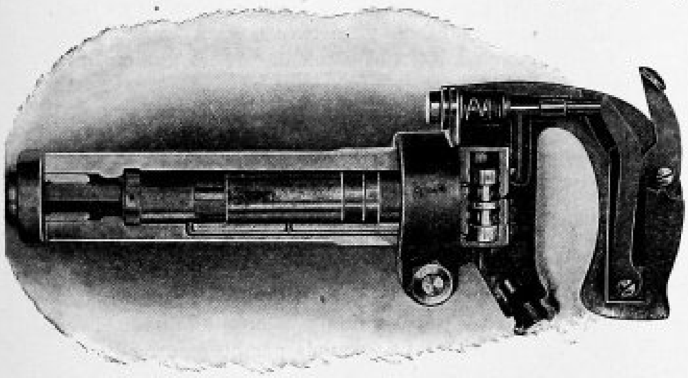
THE "CROWN" HAMMER.

The distinctive features of different makes of pneumatic hammers are usually found in the mechanism of the valves or means for admitting air to the cylinders.

The valve in the Crown hammer, manufactured by the Ingersoll-Rand Drill Company, New York, is a plain spool shape, hardened and accurately ground to a uniform diameter. Where the diameter is reduced to provide air passages the reduction is secured by wide fillets, which leave no opportunity for a weak cross-section or shrinkage flaws. It is extremely light, weighing less than an ounce, therefore, in operation the vibration due to its movement is not perceptible. It operates in a valve box, which is a solid piece of hardened and ground steel bored transversely with a hole of uniform diameter in which the valve travels. The air ports are simply drilled holes of ample diameter and of the least possible length. After the valve has been inserted in the valve box, the valve box sleeve, which is a ring of steel, is forced over the box and registers in position with a dowel pin, which prevents any possible shifting and consequent interference with port openings.

The distinctive feature in the action of the Crown hammer is that the movement of the valve is produced by unbalanced pressures on its two ends, the valve and seat being of uniform diameter. On one end a pressure lower than the full working pressure is constantly maintained; and on the other end the full working pressure is intermittently applied. By a special process the interior or bore of the cylinder of this hammer is hardened and ground, while the outside is left soft and tough. The ports are drilled from the inside of the bore, in order to avoid plugged openings, which frequently give trouble, since the plugs are apt to work loose, and since the recesses left in the cylinder bore accumulate grit and score the surface of the piston.

A circular screen of unusually large diameter is inserted in a recess in the handle next to the valve box. In this position it is entirely out of sight and out of reach of the operator, who cannot remove it or injure it without entirely dismantling



SECTION SHOWING SPOOL-SHAPED VALVE OF CROWN HAMMER.

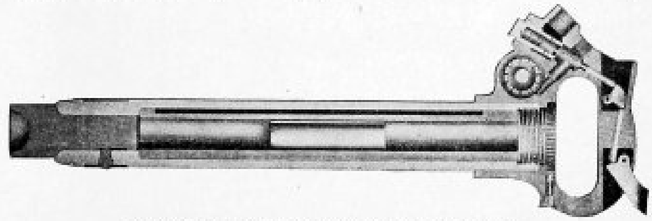
the hammer; and since it is of unusually large diameter it is much less likely to become clogged up with dirt, thus cutting down the air supply to the hammer. When it does become filled with dirt it can easily be removed and cleaned by blowing a jet of air through it in the opposite direction from that in which the air usually passes through it.

THE MONARCH RIVETING HAMMER.

In the Monarch riveting hammer, manufactured by the Standard Railway Equipment Company, St. Louis, Mo., the barrel or cylinder has an inner bushing, which permits the port holes extending through the cylinder to be milled instead of drilled as is usually done. By this means the danger of getting the ports too close together or too close to the inner wall of the barrel, and thus causing the metal between to blow out and ruin the machine, is entirely obviated. It also reduces the possibility of the air passages being obstructed by shavings, thus impairing the working of the machine by interrupting the flow of air. In the complete tool there are but two moving parts—the valve and plunger. The valve is of the solid type and has a maximum travel of a quarter of an inch, operating in the same direction as the piston. It is claimed that owing to the solid construction of the valve it will outlast those of a lighter design, and that the short travel reduces the liability to crystallize, and that the movement being in the same direction as the piston, reduces the vibration resultant from the impact of the blow on the rivet set, so that instead of jarring the valve steadies the hammer. The general design of the Monarch hammer is neat in appearance and symmetrical in detail. The hose connection is situated on the upper part of the grasping portion of the handle, thus affording ample opportunity for low horizontal work.

PITTSBURG RIVETER.

The hammer manufactured by the Pittsburg Pneumatic Tool Company, Pittsburg, Pa., has features in points of construction entirely unlike any other type of riveting hammer, and in general design is of an attractive and distinct type. The cylinder is composed of an interior sleeve threaded on the upper or handle end and screwed into the exterior cylinder. It is also provided with a milled top that is utilized for locking the handle securely in position, by means of a set-screw running

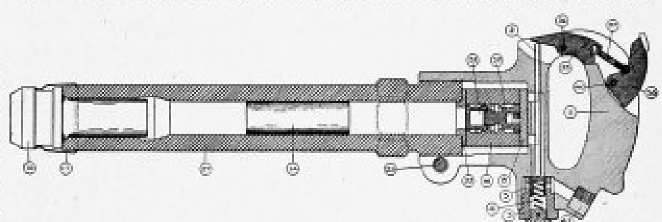


SECTIONAL VIEW OF PITTSBURG HAMMER.

through the lower portion of handle. The valve and block being located in the head-block or handle is easy of access, and is ready for inspection when necessary by simply lifting a locking pin and unscrewing the valve cap screw. It is not necessary to disconnect a locking nut or remove the handle in order to get at the valve. The hammer is also provided with an arrangement for holding a rivet set securely in place, without the necessity of utilizing the rivet-set springs usually required. The valve, which is of the solid type, moves at right angles to the piston, consequently the vibration does not influence it. Owing to the fact that the valve is located on the exterior of the hammer, it has been possible to reduce the over-all length of the hammer to a minimum.

THE CLEVELAND HAMMERS.

The riveting hammers manufactured by the Cleveland Pneumatic Tool Company, Cleveland, Ohio, under the name of "Cleveland," "Ajax" and "Jumbo," are of the same general construction but of different degrees of power. They are operated by means of a solid valve, located in the usual valve box, covered by a cap, and the whole placed on the end of the cylinder and secured in place by the handle, which is screwed and clamped to the cylinder. The valve operates in the same plane as the piston, cushioning the piston on the return stroke

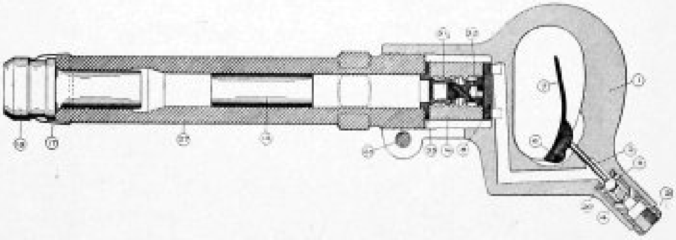


SECTION OF CLEVELAND RIVETER WITH OUTSIDE TRIGGER.

so as to prevent vibration when in operation. The air is delivered through the upper back end of the grasping portion of the handle, passes entirely through the handle, and is applied directly on top of the valve. As shown by the illustrations these hammers are made in styles with inside and outside latch or trigger. They may be easily distinguished from other makes in outward appearance by the long head block or handle.

THE GREEN RIVETER.

A hammer that is very simple in construction is manufactured by the Dayton Pneumatic Tool Company, Dayton, Ohio, under the name of "Green." These hammers are all of the same general design, so that all parts with the exception of the cylinders are interchangeable. This, together with the fact that an absence of complication is obtained by reason of few parts, results in a minimum cost for maintenance. The valve mechanism of the "Green" hammer is considered very simple. It is of the double piston type, similar to a locomotive piston valve. The live air taken past the ends exhausts through an annular space between its two heads. It is positive in its action, being perfectly balanced, and at the end of each stroke makes a flat seat, thus reducing the possibility of



SECTION OF CLEVELAND HAMMER WITH INSIDE TRIGGER.

leakage from wear to a minimum. The most notable feature of the "Green" hammer is the avoidance of the valve block, common to most pneumatic hammers, the valve itself being placed in a vertical position in the head-lock of the handle. The throttle valve is located directly behind the main valve. By this arrangement there is a direct passage for the air from the hose to the hammer cylinder, consequently a high cylinder pressure. In the event of the hammer becoming inoperative, by means of the valve sticking, it is easily accessible and can be removed without disconnecting the handle from the cylinder. The throttle valve is of the poppet type, accurately balanced and graduated, to insure a reasonable control of the hammer. These hammers are made with either an inside or an outside trigger.

(To be continued.)

Boilers of the Swiss Lake Steamers Blümlisalp and Rhein.

The practice of installing superheaters in Scotch boilers is becoming more general every day, especially in connection with slow-speed, long-stroke engines. An instance of this is shown in the case of the boilers of the new Swiss Lake steamers *Blümlisalp* and *Rhein*, recently built by Escher Wyss & Company, Zürich, Switzerland. These boats are each 197 feet long, 22.3 feet wide with a depth of 9 feet, and have a speed of about 15 knots. Propulsion is obtained by means of paddle wheels driven by a two-cylinder, compound, inclined engine, working under a steam pressure of 147 pounds per square inch. The diameters of the cylinders are 26¼ inches and 45¼ inches with a stroke of 45¼ inches.

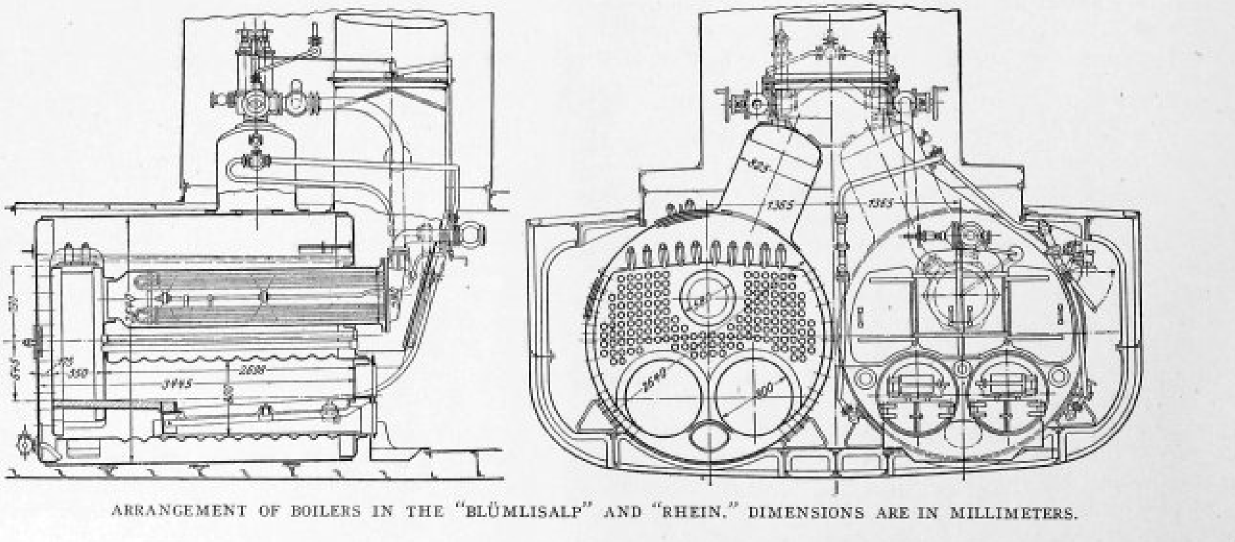
Steam is furnished by two cylindrical boilers fitted with superheaters of the Schmidt type. Each boiler is provided with two furnaces, 154 evaporation tubes, and 60 superheating tubes, and is surmounted by a steam dome. The boiler shell is in each case made of a single plate with triple riveted joint. The heating surface measures 118.9 square meters (1,280 square feet), the superheating surface, 28.4 square meters (305 square feet) and the grate surface 2.88 square meters (31 square feet). The ratio of direct heating surface to grate surface is 41.3 to 1; while the ratio, including the superheating surface, is 51.1 to 1. The 154 tubes have external and internal diameters of 76 and 69.5 millimeters (3 and 2¾ inches). The 60 superheating tubes have an external diameter of 28 millimeters (1.1 inches), and an internal diameter of 20 millimeters (0.787 inch). The steam space has a capacity of 2.5 cubic meters (88 cubic feet).

The superheating tubes are placed within a flue contained within the boiler, and measuring 580 millimeters (22¾ inches) in diameter. This flue forms a portion of the water heating surface, as a portion of the furnace gases passes through it on their way to the uptake, performing the duty of superheating the steam while in passage. The flue lies in the midst of the upper rows of heating tubes. The two Morison suspension furnaces have each an internal diameter of 800 millimeters (31½ inches). The diameter of the boiler is 2.64 meters (8 feet 8 inches), and its length is 3.445 meters (11 feet 3 inches). The steam domes are 825 millimeters (32½ inches) in diameter.

As can be seen from the illustration the restricted height of the machinery space necessitated a somewhat unusual arrangement in the location of the steam domes on the boilers.

The *Blümlisalp* made on trial trip 620 horsepower, giving a mean speed of 26.15 kilometers (16.27 miles) per hour, or 14.1 knots. The coal consumption was 455 kilograms per hour, which figures out at 1.62 pounds per horsepower-hour. Under forced draft a speed of 29.2 kilometers (18.15 miles) per hour, or 15.7 knots, was reached.

The *St. Gallen*, a sister ship of the *Rhein*, with a load of 5 tons of coal on board and complete equipment, and having a mean draft of 1.27 meters (4 feet 2 inches), made a mean speed between Bregenz on Lake Constance and Ludwigshafen on the Rhein, a distance by lake and river of about 275 miles, of 26.82 kilometers (16.67 miles) per hour, or 14.45 knots, with a coal consumption of 482 kilograms (1,062 pounds) per hour, and the engines developing 633 indicated horsepower. The coal consumption was here 1.68 pounds per horsepower-hour.

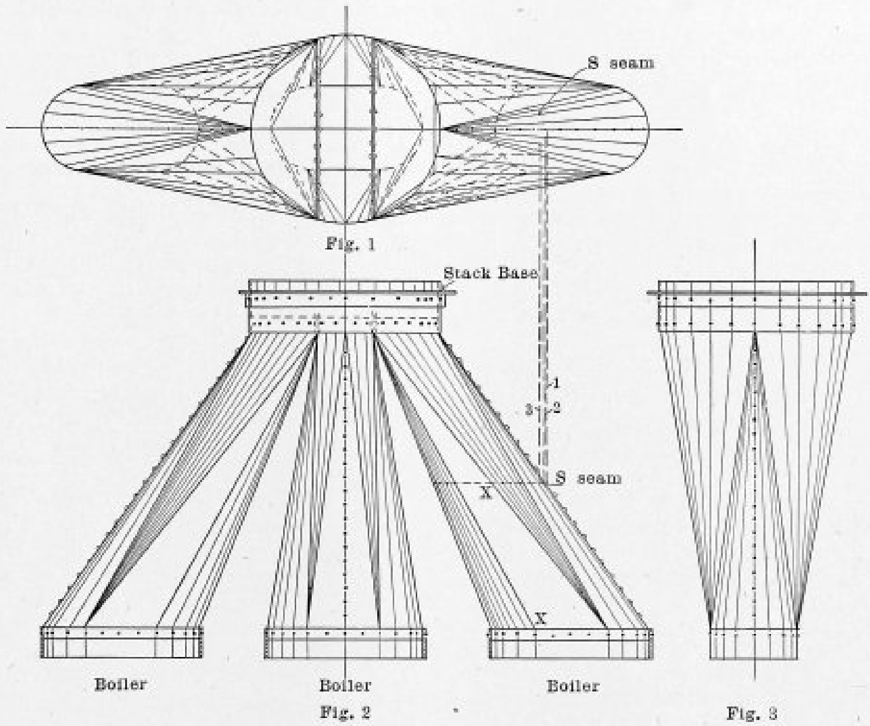


ARRANGEMENT OF BOILERS IN THE "BLÜMLISALP" AND "RHEIN." DIMENSIONS ARE IN MILLIMETERS.

Layout of an Up-Take.

BY J. N. HELTZEL.

Fig. 1 is the plan view, Fig. 2 the side elevation and Fig. 3 the end view of the up-takes from a battery of three boilers to a round stack. It is not necessary to use these views in developing the patterns, but they serve to show the shape of the completed article, and the number of plates of which it must be constructed. If the up-take were of very large dimensions these views would be necessary, because there would be a girth seam at S, Fig. 2, which it would be necessary to locate in both plan and elevation in order to get the shape of the plates of which the two sections of the tube are to be constructed. This could be easily located by projecting the points where the seam line intersects the diagonal lines which divide the surface into triangles to the corresponding lines in the plan view. A few of these points have been thus projected, as shown by the dotted lines. Making the tubes in two sections with the girth seam at S complicates the work of triangulation, since the surface of the tube would have to be divided into a different series of triangles above and below the girth seam.

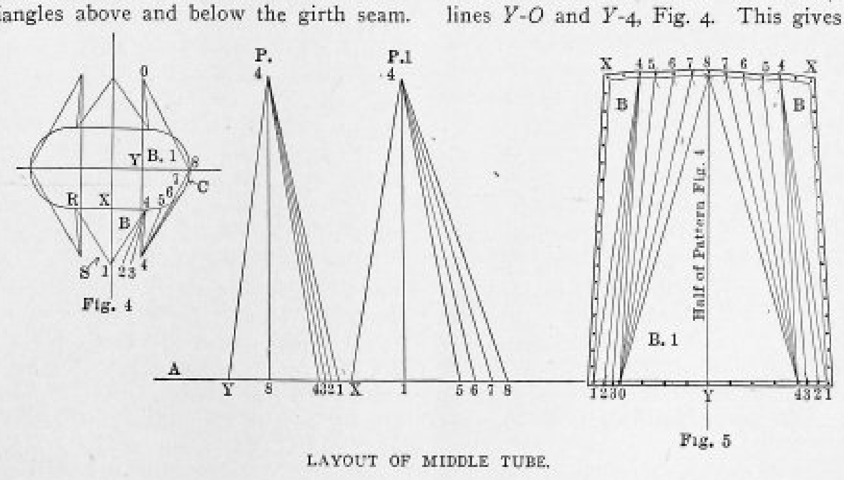


PLAN, SIDE AND END ELEVATION OF UP-TAKE FROM THREE BOILERS TO SINGLE STACK.

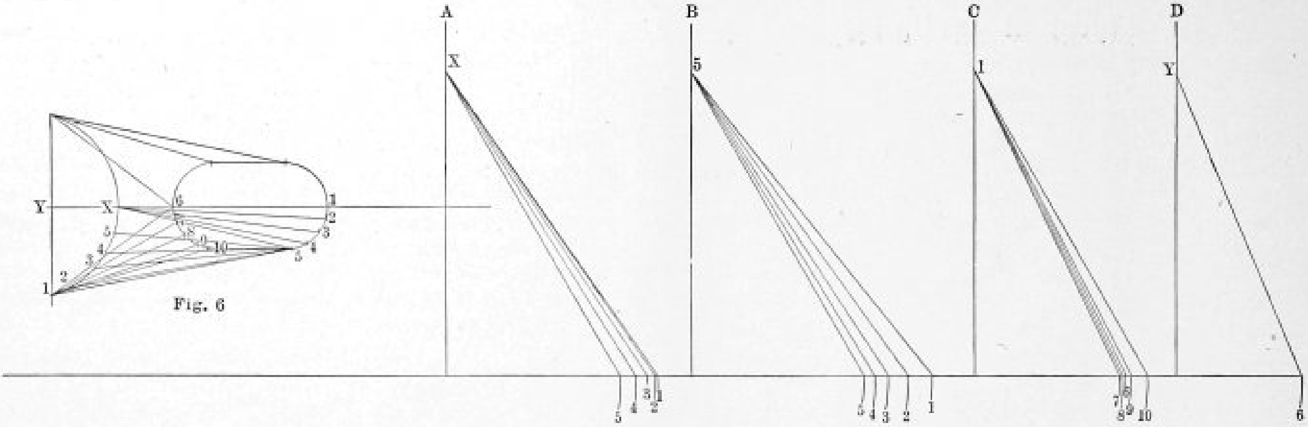
To begin the actual work of laying out the pattern draw Fig. 4, which represents a plan view of the middle tube. Space one-half the semi-circle into any number of equal parts and one-half the large circle into the same number of equal parts. Lines 4, 5, 6, 7 and 8 terminate at 4 in the large circle S, while lines 1, 2, 3 and 4 terminate at 4 in the semi-circle C. Draw the horizontal line A and at any point erect a vertical line, as 8-4, equal in length to the height of the tube. With the trams set at the point 4 in the semi-circle C take the length of the lines 1, 2, 3 and 4, and transfer them to the horizontal line from the point 8, as shown in the diagram P. Connect these points with the point 4. Do likewise with line Y-8, Fig. 4, which will give the height for the flat portion B_1.

Erect another vertical line 4-1, diagram P_1, the same height as 8-4 in diagram P. With the trams set at the point 4 in the large circle S, Fig. 4, get the length of various lines and transfer them to diagram P_1, as in the preceding diagram. Also transfer the length of line X-1, Fig. 4, which is the length of the flat portion B.

Draw the vertical line Y-8, Fig. 5, equal in length to line 8-4, diagram P, and lay off Y-O and Y-4 equal to the length of lines Y-O and Y-4, Fig. 4. This gives the flat portion O-4 8,



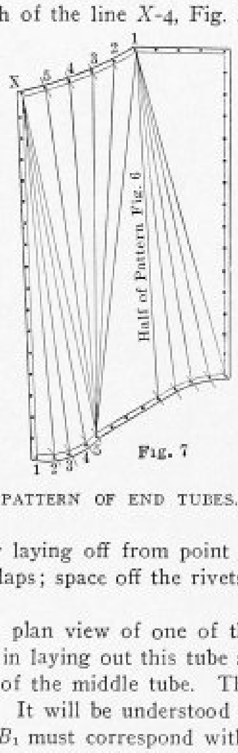
LAYOUT OF MIDDLE TUBE.



TRIANGULATION OF END TUBES.

Fig. 5. Take the length of lines 8, 7, 6, 5 and 4 and lay them off from points *O* and 4 of the pattern, spacing the distances between points 8-7, 7-6, 6-5, etc., equal to the length of the equal spaces in the large circle. After the point 4 has been reached, 4 will be the termination of the lines 1, 2, 3 and 4 instead of point *O*. Lay off these lines in a similar manner to that in which the lines 8, 7, 6, 5 were laid off, completing the curved portion of the pattern.

To lay out the remaining flat portion *B*, lay off from point 1, Fig. 5, the length of the line *X*-4, Fig. P_1. Then the point



PATTERN OF END TUBES.

X is established by laying off from point 4 the distance 4-*X*. Add the necessary laps; space off the rivets and the pattern is complete.

Fig. 6 shows the plan view of one of the end tubes. The principles involved in laying out this tube are the same as we used in the layout of the middle tube. The complete pattern is shown in Fig. 7. It will be understood that the rivet holes in the flat portion B_1 must correspond with the rivet holes in the flat portion B_2. All holes can be punched in the flat plates before the material is bent.

Magnetic Hoists.

Hoisting magnets are coming into great favor in British iron works, and are finding some use in American shops. Castings weighing 2 or 3 tons are lifted by electro-magnets. Much time is saved in comparison with the use of hooks, slings and other devices, as the mere throwing of a switch energizes the magnet, and the apparatus is able to hold on without any catching and securing devices. The principal drawback to this form of apparatus is the lack of safety, for, if for any reason the electric current is broken, the load at once drops from the magnet.

Cutting and Welding Steel with the Oxy-Acetylene Blowpipe.

A few months ago we published a description of cutting steel by a combustion process (see page 46, February, 1907,) in which the oxy-hydrogen blowpipe was used. In this operation the flame from the oxy-hydrogen blowpipe was followed immediately by a jet of oxygen, which easily maintained combustion with the metal heated by the oxy-hydrogen flame. The metal being reduced to a fluid state by this combustion, flowed from the path of the flame, leaving a clean cut.

A more recent development along the same line, but one which has a wider application, since it can be used to better advantage for welding iron or steel, is the use of the oxy-acetylene blowpipe. Acetylene is an endothermic gas consisting of hydrogen and carbon. In a properly regulated blowpipe the acetylene splits up into its constituents at the base of the flame, only the carbon taking part in the combustion, because hydrogen will not combine with oxygen at the high temperature at which carbon burns in oxygen. The hydrogen remaining free forms a protection to the nozzles of the blowpipe where the carbon is burning, which is the point of maximum temperature. With the oxy-acetylene blowpipe a temperature of over 7,000 degrees Fahrenheit has been obtained, as compared with the temperature of from 3,500 to 4,500 degrees Fahrenheit obtained with the oxy-hydrogen blowpipe. The heat developed in the oxy-acetylene flame, besides being almost twice as intense, is nearly five times as great as in the oxy-hydrogen flame.

In actual use, the oxy-acetylene blowpipe is cheaper and simpler for welding than electricity, and the welding can be effected without altering the character of the metal, while electric welding tends to injure the metal and make it brittle, so that the results obtained are always uncertain. One of the principal advantages of the blowpipe system of welding metal by simple fusion is that, since the heat can be applied locally, the various parts of a complicated structure can be fitted together and welded in position. On the other hand, this local heating is a disadvantage in such structures as steam boilers, since it sets up unequal stresses in the plates, which are apt to result in failures. If it were possible to anneal the entire structure this objection would, of course, be removed.

There are two types of oxy-acetylene blowpipes in use. The high-pressure mixed jet, and the injector jet, or low-pressure blowpipe. In the high-pressure mixed jet pipe the supply of both oxygen and acetylene are under pressure. This is a more expensive apparatus to use, since it is necessary to use dissolved acetylene, and therefore it cannot be connected directly with an acetylene generator. Furthermore, it uses a greater quantity of acetylene gas for a given amount of work, With the injector jet, or low-pressure blowpipe, a more intimate mixture of the two gases is obtained than in the high-pressure type, and therefore better efficiency is secured. Blowpipes of this type are now produced commercially appropriate for welding plates from 1/32 to ¾ inch in thickness. The cost of welding by this process varies largely with the nature of the work and the capacity and skill of the workman, but on the whole it is said to compare favorably with the cost of riveting.

Plates of iron and steel from 20 gage upward when welded together with the blowpipe have proved stronger at the joints than in the body of the plate. The following table gives some idea of the speed with which such work may be performed.

Thickness of Plate.—Inch.	Foot-Run per Hour.
3/64	35
⅛	20
⅜	10
½	6

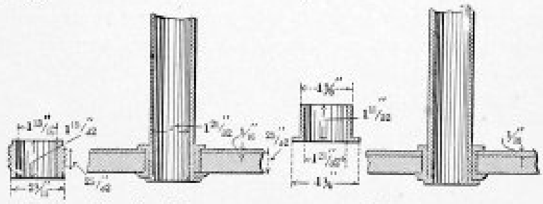
These figures are average results obtained when working on cold plate. By previously heating the piece to be welded in the neighborhood of the joints the time and cost of making the weld may be reduced from 30 to 50 percent in the case of plates ¼ inch thick and upward.

The Repair of Locomotive Tube Plates.

An article published in the *Bulletin* of the International Railway Congress Association, by S. Ragno, Inspector of the Italian State Railways, describes a system of repairing the copper tube plates of locomotive fire-boxes by means of thin sheet copper patches secured by plain copper ferrules. In the case of a plate with few cracks in the interspaces, and when these cracks do not extend right through the plate, it is recommended that attempts should be made to close the cracks by expanding the tube ends, and to force the bead against the cracks. If, however, the tubes are worn and burnt at the beads, the author advocates replacing those tubes next to the cracks and beading them over so that the beads touch and cover the cracks. This method, it is stated, may prove useful when a few cracks are just beginning to form, and the majority of the tubes are in a good condition, so that the tubes can continue to be used until the repair of the tube plate is undertaken.

The excellent results which, it is said, are obtained with this particular system of repairing tube plates are chiefly attributed to the fact that thin sheet copper is used for the patching. At first sight it might appear that the use of thin copper would result in a loss of strength, corresponding to the damage in the interspaces of the plate; but it is pointed out that the perforated part of the plate being supported by the tubes is only subjected to very small stresses produced by the internal pressure. It is therefore contended that in selecting a repairing system it is not necessary to consider how to restore the strength of the plate at the places where the cracks are, but it is simply necessary to restore the original tightness. From a study of the diagrams showing the general position of the cracks in tube plates, it appears evident that the cracks are chiefly caused by movements due to expansion and contraction, and not to want of strength of the interspaces considered separately. Were the cracks produced by weakness in the plate, they would be distributed indiscriminately, which is not usually the case in practice. In order to secure thick patches to the tube plates needing repair, screwed ferrules were formerly used as shown in Figs. 1 and 2; with thin patches, however, plain copper ferrules, as shown in Figs. 3 and 4, have been found suitable. These simply consist of pieces of copper tube which are cut off and put in place, and expanded into the holes in the tube plate by means of a Dudgeon roller or other tool. The two beads are then carefully made, particularly the one inside the boiler, so as to ensure the true position and correct adhesion of the patch of thin copper.

When the interspaces are much damaged, particularly if they have already been repaired, or the tube plates have become deformed, it is advised when applying the thin sheet to use screwed plugs in the holes adjoining the interspaces where there is much damage. These plugs, which hold the damaged interspaces on both sides, form a united whole, and at the same time the thin copper sheet prevents any possible leakage. A type of plug used with considerable success is shown in detail in Fig. 5. The secret of satisfactorily repairing tube plates by this method, it is stated, consists in the selection of



Figs. 1 and 2 Figs. 3 and 4

THIN COPPER PATCH SECURED BY COPPER FERRULE.

sheet copper from 1/16 inch to 3/32 inch thick; a greater thickness is said to be absolutely useless and injurious. The arguments in support of this statement are that a patch 13/64 inch to 19/64 inch introduced into the boiler is placed against the tube plate. It must then be taken to the drill, and afterwards have its face fitted by means of chipping and filling. By these different operations it has been found that the patch always becomes somewhat distorted, so that when it is ready to go on to the plate the holes no longer quite agree, and a certain amount of tapping is required to get the holes opposite one another without increasing other deformation. Further, if the patch is large—as it frequently is—it is necessary to bend it several times in passing it into the boiler, which, in the case of thick copper, tends to deform it permanently, and there is even a risk of fracture. Also, in order to get patches into place, they

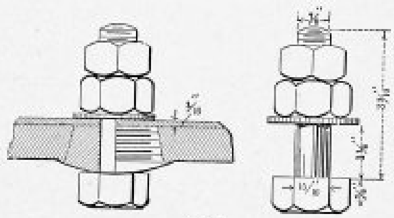


Fig. 5

THIN COPPER PATCH SECURED BY PLUG.

must be drawn against the plate by means of bolts and nuts through the holes.

It is thus contended that the method of fitting thick patches is in itself responsible for defective adhesion, which may be overcome by calking; but owing to the irregularity of shape this is not always successful.

A patch 1/16 inch to 5/16 inch thick is first carefully annealed, and is then applied to the surface of the tube plate and pressed against the holes; it is provisionally fixed by bolts and nuts, and light blows are given with a hammer at the holes, swelling out these places a little and pressing them into the plate. While the patch is in position the holes are cut by means of a chisel, and the edge of the patch finished off, which latter becomes calked along the edge by the cutting. Another point which has been found advantageous is that the work being done on the patch when in position helps to make it adhere tightly to the plate. With thin sheet copper 1/16 inch to 5/64 inch thick, 3/32 inch to ⅛ inch copper ferrules are found satisfactory and are well proportioned; whereas when screwed ferrules are used and a thick patch, the relative sizes are unsatisfactory. Moreover, the plain ferrules are much less expensive than the screwed type.

It is stated that under the most unfavorable conditions when the tube plates have been in a very bad condition, only fifteen to twenty days' work have been required to take out the tubes and to put a patch over eighty or ninety holes, and put the tubes in again; and at the same time other minor repairs have been carried out.

The operation in the case of the larger patches—viz., up to ninety holes—costs from $58 to $78 for material and labor; in the smaller and more usual cases—viz., twenty to fifty holes—the cost is said to be very much less.

One precaution which the author strongly urges is that the surface of the plates to which the patches are to be applied be thoroughly examined, and after the patch has been applied, all ferrules should be tried by tapping them inside with a hammer to see that they are tight.

The Detroit River Tunnel.

An interesting job of sheet metal construction is under way at Detroit, where a sub-aqueous tunnel is being built under the Detroit River, between Detroit and Windsor, for the Michigan Central Railroad. Due to the nature of the bed of the river, which is principally of soft blue clay, it was found impossible to bore the tunnel in the ordinary way except by going so far beneath the bottom of the river that the grades would be excessive. For this reason it was decided to construct the tunnel in the form of steel tubes, which could be built in sections on shore, conveyed to their proper location, sunk into position on the bottom of the river, and there imbedded in concrete. In order to leave the proper depth of water over the top of the tunnel required by law for navigation on the river, it was first necessary to dredge a ditch across the river so that the steel tubes could be lowered below the bed of the river. Thus, in places the tunnel is only partially below the level of the river bottom.

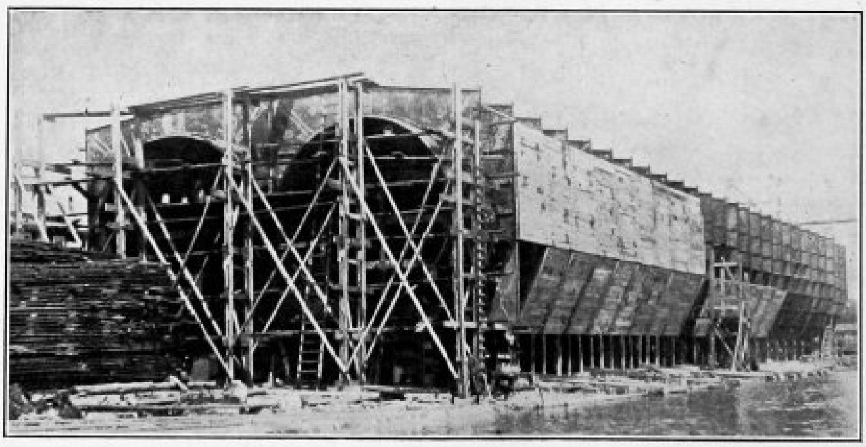
The tunnel consists of two steel tubes 23 feet 4 inches in diameter, placed side by side and imbedded in concrete. The tubes were built at the St. Clair yards of the Great Lakes Engineering Works in sections each 250 feet long. The construction of the tubes is clearly shown in Fig. 1, where one of the sections may be seen on the stocks in the builders' yard. Each section consists of circular rings of ⅜-inch steel plate, with a web girder or diaphragm all around it. These diaphragms are spaced 12 feet apart and serve to stiffen the tubes as well as hold the two tubes in their relative positions and provide a support for the bed of concrete which surrounds it. After being placed in position the tubes are lined with concrete 20 inches thick, leaving an inside diameter of 20 feet, an ample clearance for the single track which each tube is to contain.

When a section of the tubes is completed, the ends are closed with wooden bulkheads, and the outer edges of the diaphragms are planked solid with 3-inch planking, after which the section is launched into the river. The air contained in the tubes, together with the wooden planking on the diaphragms, provides sufficient buoyancy for the section to float. It is then towed down the river to the position which it is to occupy. The air is allowed to escape from the tubes and it is sunk into the ditch which had been previously dredged in the bed of the river. On top of the tubes and fastened to them are four temporary air cylinders, each about 10 feet in diameter and 60 feet long, which are filled with compressed air. These aid in maintaining the buoyancy while the tubes are being sunk, and are afterwards detached and used again on the next section.

After a section is in place it is joined to the section previously laid down. A tight joint is obtained by the use of a heavy rubber gasket, placed in a partially cylindrical chamber, which is sealed with cement. After a section is in place, the space between the tubes and the planking on the edges of the diaphragm is filled with concrete, while the space outside of the planking between that and the edge of the ditch or trench is filled with sand and gravel and covered over with loose stone.

The total length of the sub-aqueous portion of the tunnel is 2,622 feet. At the Detroit end there is a land tunnel 2,129 feet long, and beyond that an open-cut approach 1,540 feet long, while at the Windsor side there is a land tunnel 3,192 feet long, and an open-cut approach 3,300 feet long. Thus, the total length of the tunnel, including the open cuts, is 12,783 feet, or nearly 2½ miles.

Work on the tunnel is progressing rapidly at the present time, and it is expected that before the end of the year the Canadian end will be completed and the last section of steel tubes sunk in place. It is estimated that the tunnel will be completed by June, 1909.



A SECTION OF THE STEEL TUBES FOR THE DETROIT RIVER TUNNEL ON THE STOCKS AT THE BUILDERS' YARDS.

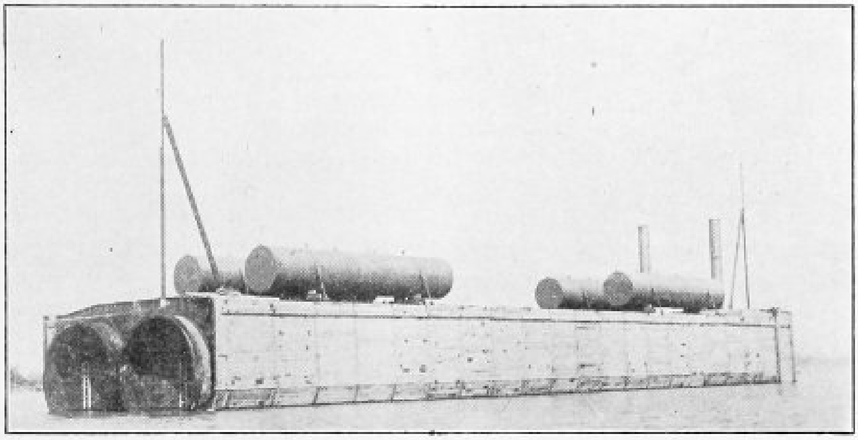
In order to test the effect of vanadium upon steel, a mild steel free from phosphorus, with a tensile strength of 30 tons per square inch and 17 percent elongation, was melted in a graphite crucible. It thereupon became carbonized, and showed 61 tons tensile strength and 23 percent elongation. On adding 1 percent of vanadium the tensile strength was raised to 69 tons, with an elastic limit of 50 tons and 7.3 percent elongation.

The Boilers of the New Steamships Delaware and Pawnee.

The two new steamships *Delaware* and *Pawnee* built for the Clyde Steamship Line by the Harlan & Hollingsworth Corporation, Wilmington, Del., are attracting considerable attention on account of their speed and economy. The ships are 267 feet long, 40 feet wide with a draft, at a displacement of 2,840 tons, of 15 feet 6 inches. They are of the single-screw type, driven by three-cylinder, vertical, inverted, direct-acting, triple-expansion engines with cylinders 19, 30 and 50 inches in diameter with a stroke of 30 inches.

The steam generating plant consists of two single-ended Scotch boilers, designed for a working steam pressure of 175 pounds per square inch gage. There is one smoke-pipe, having a diameter of 4 feet 6 inches and a height of 50 feet above grates. There is provided a system of forced draft, designed by the Harlan & Hollingsworth Corporation. The principal dimensions of the boilers are: Diameter, inside, 12 feet 4 inches; length, 10 feet 8 inches; thickness of shell, 1 1/16 inches; shell rivets, 1⅛ inches; rivet percentage of strength, 95.5; plate is 81.7 percent.

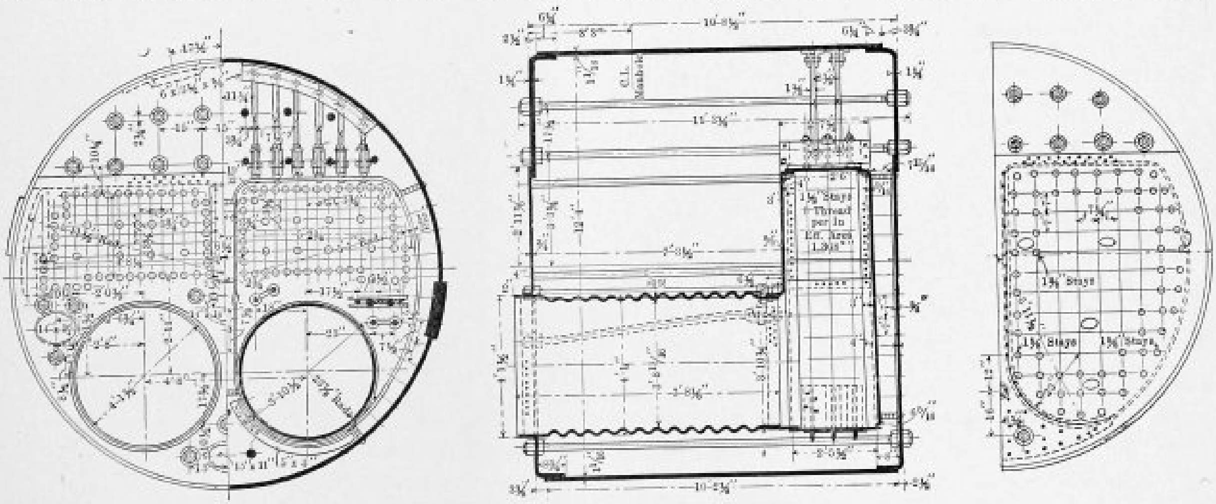
Each boiler is fitted with two 45-inch Morison suspension furnaces, 7 feet 8⅛ inches long, each having its own combustion chamber. There are 280 2½-inch tubes in each boiler, made up as follows: Fifty wrought iron stay-tubes, No. 5 B. W. G.; 230 wrought iron ordinary tubes, No. 9 B. W. G. Each boiler has seventeen through stays 2⅝ inches diameter; eight 2½-inch stays from front head to front wall of combustion chamber, and twenty-four double refined iron suspension stays, 1½ by 2 inches. The grate surface in each boiler is 43.12 square feet; heating surface, 1,651.6 square feet; with a ratio of heating surface to grate surface of 38.2 to 1. The area through tubes, 1,031 square inches, is equal to 25 square inches per square foot of grate. or a ratio of 1 to 5.76. The heating surface is made up as follows:



TOWING A SECTION OF THE TUBES FROM THE BUILDERS' YARDS TO THE SITE OF THE DETROIT RIVER TUNNEL.

	Square Feet.
Two hundred and eighty 2½-inch tubes...	1,316
Furnaces	103.7
Combustion chamber	205.7
Front tube plate.......................	26.2
Each boiler	1,651.6

The ratio of grate surface to cross-section of smoke-pipe is 5.42, being $2 \times 43.12 \div 15.904$. The designed evaporation of water is 240 pounds per square foot of grate per hour. Each boiler has one safety valve, 4½ inches in diameter.



TYPE OF BOILER USED ON STEAMSHIPS "DELAWARE" AND "PAWNEE."

The construction of the boilers is a good example of the effect of the amendment of the general rules and regulations passed by the Board of Supervising Inspectors of the United States Government in January, 1906. It will be remembered that one amendment, which went into effect at that time, but which has since been repealed, provided that the tops of the combustion chambers and back connections of all boilers whose construction was commenced after June 30, 1906, subject to a pressure of 160 pounds per square inch and over, should be suspended from the top of the shell. The tops of each combustion chamber in the boilers of the *Delaware* and *Pawnee* are braced by six girder braces having a bearing on the tube plate and back sheet of the combustion chamber. Each girder is, however, suspended from the top of the shell by means of two 1½-inch sling stays fastened to the shell of the boiler with double angles. This form of construction takes nearly all of the combustion stress off the tube sheet and back plate of the combustion chamber, but is, however, an unnecessarily strong construction.

Tube Setting.

Tubes give so much trouble from leakage that, regardless of the cause of leaks, boiler makers are always looking for some better method of making a tight joint between the tube and the tube sheet. The result of all the discussion, criticism and suggestion on this subject in this country has been to bring about a fairly uniform method of doing the work. The illustration (Fig. 1) shows the method used by the Union Pacific Railroad, and since this is practically the same method as that employed in the majority of railway boiler shops, it will be worth while to study it carefully.

It is absolutely necessary for a good job that all scale should be carefully removed from the end of the tube and from the inside of the hole of the tube sheet. A copper ferrule, or shim, is then inserted in the hole and expanded lightly in place. This ferrule should either be flush with the fire side of the tube sheet, or, better still, should have about 1/32-inch chamfer from the tube sheet towards the inside of the boiler. The other end of the ferrule should project a slight distance into the boiler, not more than ⅛ inch. The tube is then inserted and expanded in place, the end projecting about ¼ inch through the tube sheet.

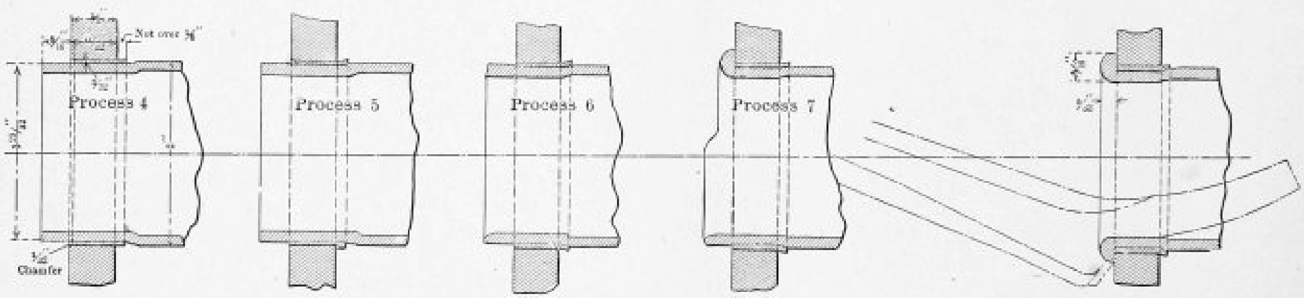


FIG. 1.—METHOD OF SETTING TUBES USED BY UNION PACIFIC RAILROAD.

There is some difference of opinion among boiler makers in this country regarding the use of a roller expander, whether it should be used before or after the sectional expander has been used, or whether it should be used at all. These differences of opinion are, however, of minor importance. The main thing to be remembered is that excessive use of the roller expander tends to wear out the end of the tube and make it so thin that its life is very much shortened. After the flue has been brought in perfect contact with the sheet the further use of the expander or roller will not make the flue any tighter, but will reduce the thickness of the metal and decrease its ductility. The less work done on a flue, the longer it will last.

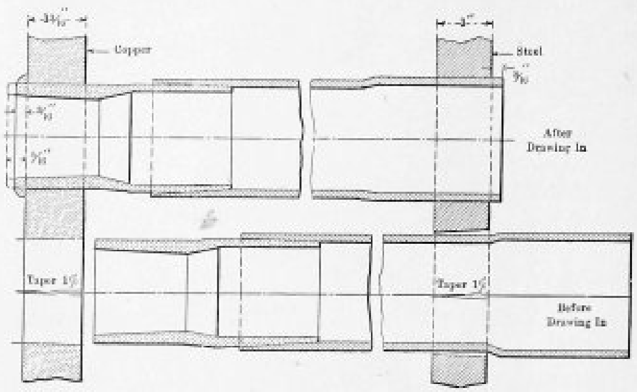


FIG. 3.—TUBE USED ON ROYAL BAVARIAN STATE RAILROAD.

In England, France and Germany only roller expanders are used, while on American railroads about 60 percent favor the sectional expander and 40 percent the roller expander.

The Lancashire & Yorkshire Railway of England use a ferrule in the firebox end of the tube, as shown in Fig. 2. The ferrules are welded and made from Swedish high-carbon steel, and are driven in by an ordinary drift pin. The tube is not beaded over. The firebox tube plate is of copper 1 inch thick, while the front tube sheet is of steel ⅞ inch thick. The London & Southwestern Railway, of England, uses similar ferrules in their lower tubes, but not in the upper ones. The Southern Railway, of France, also uses ferrules in all the tubes.

The Royal Bavarian State Railroad uses a copper safe end on an iron tube. The safe end of the tube, as can be seen from Fig. 3, is very much strengthened in this way. As the hole in the tube sheet is tapered and the end is beaded over, the other end of the tube, the front end, is simply rolled.

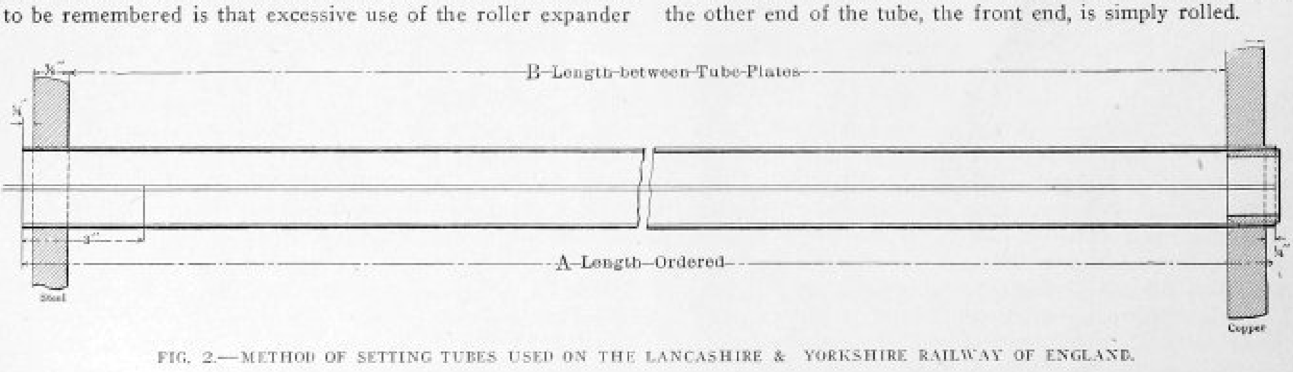
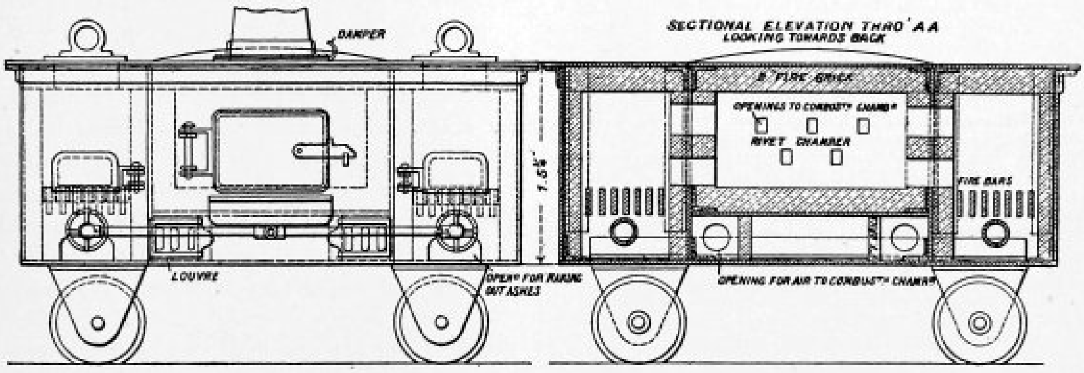


FIG. 2.—METHOD OF SETTING TUBES USED ON THE LANCASHIRE & YORKSHIRE RAILWAY OF ENGLAND.

A Portable Rivet Heating Furnace.

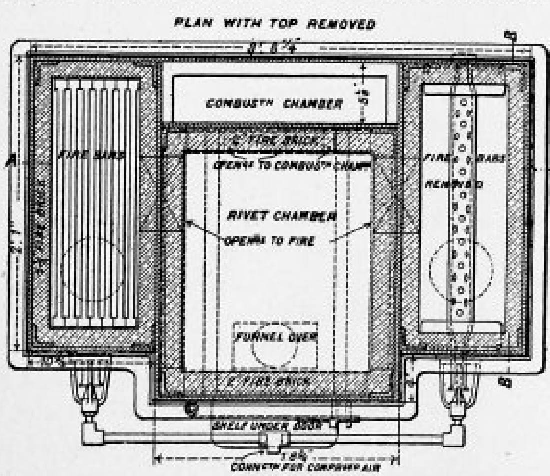
A new form of portable rivet heating furnace, which is being used to a certain extent in England, is described in a recent number of *Engineering* as follows: It will be seen from the illustrations that the furnace consists of a rectangular casing constructed of steel plates and angles, the space within the casing being divided into five compartments. The inner walls of these compartments, which are exposed to the flames, are lined with 2-inch firebrick, and the whole is mounted on wheels for the sake of portability.

The action of the furnace is as follows: The products of combustion from the two fires pass through openings in the division walls into the rivet chamber, while air is admitted at the front louvres, and passes along the trunks under the rivet chamber into the hot-air chamber at the back. During its passage it becomes heated, and in this condition leaves the hot-air chamber through the openings in the back wall and enters the rivet chamber, where it comes in contact with the flame and products of combustion from the two fires. The products of combustion pass out from the rivet chamber through a chimney located on the crown of the chamber near the front end.



EXTERIOR AND VERTICAL SECTION OF PORTABLE RIVET FURNACE.

The different compartments into which the furnace is divided are as follows: A rivet-heating chamber; two heating chambers or furnaces; a hot-air chamber at the back of the furnace and hot-air passages or trunks underneath the rivet-heating chamber. Through the walls, between the heating chambers and the rivet chamber, suitable openings are left to allow the heat to pass from the former to the latter. Openings are also left in the rear wall of the rivet-heating chamber, through which the hot air from the hot-air chamber may pass. Each heating chamber or furnace is fitted with a set of fire bars, underneath which is a fixed perforated pipe



HORIZONTAL SECTION OF RIVET FURNACE.

provided at the front end with an injector nozzle coupled to a pipe leading from a compressed air supply. At the front end of each heating chamber and at the front end of the rivet chamber a hinged firebrick-lined door is fitted, and the air chamber at the back of the rivet chamber is diverted underneath the rivet chamber by way of two channels which pass to the front of the casing, where they are provided with louvres, or air ventilating dampers.

The air supply to the rivet chamber from the hot-air chamber can be regulated by means of the louvres or dampers in connection with the air trunks, and the temperature of the furnaces may be controlled by means of valves on the pipes which supply compressed air under the fire bars of the furnaces. By this means it is claimed that the rivets are heated uniformly and rapidly.

Required Tonnage for Riveters.

The following values for pressure in tons to be used with different sizes of rivets for different classes of work have been recommended by Mr. Joseph G. Seyboldt, and are based on wide experience in all kinds of riveting:

Rivets.	Tank.	Structural.	Boilers.
1/2"	20	20	30
5/8"	25	25	40
11/16"	30	30	45
3/4"	35	35	50
7/8"	50	35	60
15/16"	65	40	68
1"	68	50	75
1 1/8"	80	65	100
1 1/4"	100	75	125
1 3/8"	115	90	150
1 1/2"	125	100	150

On any hand-power operated apparatus, such as a small jib crane, requiring a considerable exertion on the part of one or more men, the position and throw of the crank become important. Experience has shown that for the average laborer a height of shaft of 32 inches above the ground or platform, with a throw of 32 inches provided by a crank arm of 16 inches, is satisfactory. For an operation requiring only light exertion the crank length might be made only half this amount, and the crank shaft placed 40 inches above the floor level.

The Boiler Maker

Published Monthly by

THE BOILER MAKER

INCORPORATED

17 Battery Place, - - - - New York

Christopher St., Finsbury Square, London, E. C.

H. L. ALDRICH, President and Treasurer

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Branch Offices.

Philadelphia, Pa., Mach'y Dept., The Bourse, S. W. ANNESS.
Boston, Mass., 170 Summer St., S. I. CARPENTER.
Chicago, Ill., 625 Monadnock Building, H. S. MOSS.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico........	$1.00	.10
Other countries in Postal Union..........	1.50 (6/3)	.15 (—/7½)

Entered at the New York Postoffice as second-class matter.

Compressed Air in the Boiler Shop.

From the way in which pneumatic tools are handled by the workmen in some boiler shops, it would appear to the casual observer that such appliances are of no more value than an ordinary sledge hammer or drift pin. While no good mechanic would fail to realize that even the smallest and least important pneumatic tool is a delicate and expensive piece of machinery and would use it accordingly, yet when placed in the hands of an unskilled mechanic, the same tool is frequently subjected to various abuses which result in a loss of economy if not in the destruction of the tool. In order to bring to the attention of boiler makers the important points and value of such tools, we began in our November issue the publication of a comprehensive series of articles written by a practical boiler maker, describing the most important points in the design, operation and care of a number of different makes of pneumatic tools. The subject of air drills was taken up in the November issue, riveting hammers are described in the current issue and in the succeeding issues important points bearing on the operation and care of such tools will be brought out.

While the economy and usefulness of pneumatic tools have been thoroughly demonstrated and have been, in fact, the cause of their extensive use, there are some points regarding the installation of the air compressor and system of piping which should not be forgotten. Progress in the use of compressed air has been rapid, and it was only about ten years ago that this form of power began to come into general use. At that time a simple air brake pump was frequently used for a compressor. Naturally, the cost and trouble of maintenance of such a crude form of compressor was considerable. Compressed air systems are now installed in a variety of ways, some users preferring to use one or two very large units for compressing the air and then conveying the power through long, complicated pipe systems to the point where it is to be used. Others have utilized electricity and small high-speed gas engines to operate small units at the particular points where the power is to be expended. Of course, greater refinement in design can be obtained with the large compressors, and since the loss in transmitting power through long pipe lines amounts to very little if the lines are carefully inspected, tested and all leaks prevented, this is generally conceded to be the most economical installation. Compressors up to a capacity of 200 cubic feet of air per minute and a pressure of 100 pounds per square inch are usually single-cylinder, double-acting machines. Above a capacity of 200 cubic feet per minute and at higher pressures a two-stage compressor shows better economy. The duplex type with two simple cylinders, except for low air pressures, which do not warrant compounding, have nearly all been superseded by the two-stage type. A two-stage compressor compressing 100 cubic feet of free air per minute from the pressure of the atmosphere to 100 pounds gage pressure, shows a saving of about 35 percent over a single-stage compressor. The steam cylinders are generally compounded when the pressure at the throttle is 150 pounds per square inch or over.

An air compressor works with much greater economy when it can be run at moderate speed than when it is forced to high speed or beyond its normal capacity. Therefore, when installing a compressed air plant it is of the utmost importance to provide a large compressor. It is never safe to depend upon intermittent work in different parts of the shop to keep a moderate sized compressor working all the time. Sufficient capacity should be provided to supply the whole shop at the same time and provide in addition to this a large margin for an increased supply.

After the proper compressor has been installed the economy of the plant may be greatly affected by the intelligent installation of the distributing pipe lines. Above all, the pipes should be of large size, since a large sized pipe gives a good storage capacity and prevents loss of power, due to friction of the air in the pipe. Provision should be made for a drainage of moisture in the pipe, and the arrangement of the pipe should be such that an accident or leak in one section will not tie up the whole plant. The pipes should be frequently inspected and tested for leakage. Some workmen seem to have the idea that since air is free to breathe it is not necessary to economize in the use of compressed air, but it should be remembered that it takes coal to compress the air, and even a small leak, say from a 1/16-inch hole, will mean the loss of a horsepower or more.

Moisture can be prevented in the pipe system by the effectual cooling of the air after compression. Likewise dirt and grit, which are extremely detrimental to delicate pneumatic tools, can be filtered from the air by the use of suitable screens. The air cylinders in the compressor should be lubricated with an oil which has a high flash point, since an oil with a low flash point, such as is used in a steam cylinder, would become vaporized in the air cylinder, and therefore pass out of the compressor without lubricating the cylinder.

Information Wanted.

Mail matter addressed to the following members of the International Master Boiler Makers' Association has been returned to the secretary. Will anyone knowing the present address of any of these gentlemen kindly communicate with Mr. Harry D. Vought, 62 Liberty street, New York:

D. J. Grace, F. B. M., C. R. I. & P. R. R., Horton, Kan.

M. T. Herron, Philadelphia, Pa.

Thomas Kelly, Iron Mountain Railway, Argenta, Ark.

James H. Bondy, F. B. M., C. R. I. & G. R. R., Dalhart, Tex.

E. J. Reardan, Taunton Locomotive Manufacturing Company, Taunton, Mass.

W. P. Paul, Union Iron Works, Selma, Ala.

W. E. Brooks, Daniel Shea Boiler Works, Memphis, Tenn.

Charles P. Hoziea, 1514 Ingraham St., Los Angeles, Cal.

John Beever, Stationary & Marine F. B. M., Cottonwood, Minn.

M. Miller, C. M. & St. R. R., Minneapolis, Minn.

F. B. Schofield, S. P. R. R., El Paso, Tex.

J. W. Estele, Portland Company, Portland, Ore.

J. H. McGuire, R. R. B. F., Southern Pacific R. R., Los Angeles, Cal.

James J. Barr, Donaldsonville Boiler Works, Louisiana.

Edw. Hubbard, Atlas Eng. Wks., Indianapolis, Ind.

M. J. Moore, Birmingham Boiler Works, N. Birmingham, Ala.

H. Linden, 11th avenue and 10th street, South, Birmingham, Ala.

T. L. Pilkington, M. & G. R. R., Monterey, Mex.

Harry Berton, Charleston B. S. I. Wks., Charleston, W. Va.

William Mahoney, R. R. B. F., C. P. & St. L. R. R., Jacksonville, Fla.

Samuel Dyke, John Mohr & Sons, So. Chicago, Ill.

W. H. Barnes, Southern Railway, Atlanta, Ga.

J. Owens, U. P. Shops, Rawlins, Wyo.

C. E. Ruth, Box 190, Selma, Ala.

Wilfred Mernier, Anaconda C. M. Company, Anaconda, Mont.

L. P. Johnson, N. P. R. R., Denver, Col.

J. J. Brennan, Great Northern Railway, Havre, Mont.

W. Scholtz, Purmton Mfg. Co., Des Moines, Ia.

W. H. Benton, Stationary & Marine F. B. M., Three Rivers, Mich.

P. J. Mack, L. E. & W. R. R., Lima. O.

Harry Morgan, Collingwood Ship Yard, B. Dept., Toronto, Ont., Can.

H. W. Bender, C. R. I. & P. R. R., Chicago, Ill.

Robert Crimins, Stationary & Marine F. B. M., Brightwood, Ind.

George Stephens, Murray Iron Works, Burlington, Ia.

J. S. Burrows, Box 124, Havelock, Neb.

Jos. Henley, Pratt B. Wks., Chicago, Ill.

W. F. Beyer, Old Federal Building, Bay City, Mich.

L. Dillion, Stationary & Marine F. B. M., Dallas, Tex.

E. B. Woodford, B. & M. R. R., Mechanicsville, N. Y.

P. Minnetti, Hawley Down Draft F. Co., St. Louis, Mo.

W. L. Richards, D. S. & S. R. R., Drifton, O.

Theo. J. Miller, Supt., B. Dept., Am. Loco. Co., 1336 Wash. ave., Allegheny, Pa.

H. B. Applewhaite, The Portland Co., Portland, Me.

C. C. McCabdless, M. K. & T. R. R., Dennison, Tex.

Peter F. Gallagher, F. B. M., Southern Railroad, Selma, Ari.

Thomas S. Whitehead, The Pancoast Ventilator Company, Philadelphia, Pa.

Edw. McKenzie, R. R. B. F., N. Y., N. H. & H. R. R., West Albany, N. Y.

James Thompson, Philadelphia Boiler Works, Philadelphia, Pa

Charles W. Shoemaker, R. R. B. F., Toledo, St. L. & W. R. R., Frankfort, Ind.

S. Wilson, R. R. B. F., B. & A. R. R., W. Springfield, Mass.

TECHNICAL PUBLICATION.

Hendricks' Commercial Register of the United States. Size, 7½ by 10 inches. Pages, 1,215. Samuel E. Hendricks Company, 74 Lafayette street, New York. Price, $10.

This is the sixteenth edition of a book which has appeared annually since 1891. It comprises a complete list of all concerns in the United States available for the use of both buyers and sellers connected with such industries as architecture, mechanical engineering, contracting, electrical engineering, railroad work, iron, steel, mining, milling, quarrying, exporting, etc. The first edition of this register, published in 1891, contained about 500 pages, and required only eight pages to index the material. It was devoted solely to the building industry of the country. From this the publication has grown until the present edition includes over 1,200 pages, containing upwards of 350,000 names and addresses classified under 31,212 trade headings, and requiring 76 pages for the index.

As an illustration of how the system of classification makes the lists available for both buyers and sellers,— in the case of "machinists and founders," all firms operating machine shops and foundries are listed under those heads for mailing purposes. Then each firm is sub-classified under headings that cover every variety of its product. Not only has the present edition been enlarged, but the lists have been carefully revised, corrected and brought up to date.

COMMUNICATIONS.

The Cause of Broken Staybolts in Locomotive Boilers.

EDITOR THE BOILER MAKER:

My experience, comprising a good many years in active boiler making, leads me to state some facts which I have observed regarding the cause of broken staybolts in locomotive boilers. Unequal expansion is one cause. The outer shell, if under 180 or 200 pounds steam pressure, is approximately at a temperature of only about 380 or 388 degrees Fahrenheit, while the firebox side sheets, when burning oil with forced draft, will be approximately from 1,200 to 1,400 degrees Fahrenheit, a temperature at which the metal begins to soften. This softening of the metal causes it to buckle or bulge in all places except at the stiff curves on the side sheet and the corners next to the flanges where the shape of the plate makes the fire-box rigid. In those places the bolts break. If there were a wider water space the bolts would necessarily be longer. This would help to a great extent, but a flexible bolt is the best remedy. I have noticed that radial stays are not broken as frequently, as they are longer and have a chance to give.

Another cause for broken staybolts is that the boiler is securely fastened in its frame, so that when running at high speed and striking low rail joints and reverse curves there is a heavy strain on the boiler, due to this suddenly reversed lateral motion.

Another fact which tends to cause breakage is the way in which the water is fed to the boiler. I have frequently found three rows of stays under the running board on the fireman's side of the boiler, in which two-thirds of the bolts were broken. Since this is the part of the boiler into which the feed water is led, the unequal strain on the bolts can be traced directly to the poor circulation of the water.

With the continuous expansion and contraction of the side sheets of the fire-box the metal becomes crystallized and cracks. The cracks usually run in a vertical direction or in the same direction in which the water circulates. This is the opposite direction to the greatest movement of the sheet caused by expansion and contraction.

A locomotive boiler when used in stationary work usually generates about one-half the power that it does on the road, but comparatively few staybolts are broken, and the side sheets seldom bulge or buckle. This shows that locomotives are forced too hard, especially in cases where a road is short of power. J. B. HOLLOWAY.

Supporting the Tops of Combustion Chambers in Marine Boilers.

EDITOR THE BOILER MAKER:

Will you kindly submit the following discussion to the readers of THE BOILER MAKER for comment:

On page 266, Vol. VII. (September, 1907) an article was published treating at length upon the methods of supporting the tops of combustion chambers in marine boilers. It was pointed out that in the ordinary method of supporting these plates by girder stays, which are not connected by sling stays to the shell of the boiler, the entire load, due to the steam pressure on the top of the combustion chamber, is brought upon the tube sheet and back sheet, while in the case where the girders are themselves stayed from the shell of the boiler by sling stays nearly all this load is removed from the tube sheet and back sheet and carried by the sling stays. A load, due to the steam pressure on that part of the space between the edge of the combustion chamber and the first bolt in the girders must be partly sustained by the tube sheet and back sheet, but as this is very much less than in the first case, the thickness of the tube sheet and back sheet can be materially reduced.

Assuming that the flue sheet is ¾ inch thick, tubes spaced 4½ inches between centers, outside diameter of tubes 3 inches, thickness of tubes ⅛ inch, width of combustion chamber 36 inches, Mr. A. claims that in the case where the girders are suspended from the shell the compressive stress upon the tube sheet is equal to the steam pressure times one-half the distance from the tube sheet to the first bolt in the girders times the horizontal pitch of tubes. Assuming that the distance from the tube sheet to the first bolt is 6 inches and that the working pressure is 200 pounds, then the compressive stress on the tube sheet is $200 \times 3 \times 4.5 = 2{,}700$ pounds.

Mr. B. claims that the width of the combustion chamber should be a consideration, and that the following formula governs the compressive stress on the tube sheet:

If P = Working pressure in pounds per square inch.
D = Least horizontal distance between tube centers.
d = Inside diameter of tubes in inches.
W = Extreme width of combustion chamber in inches.
T = Thickness of tube sheet.
E = 13,500 pounds, allowable compressive stress per square inch.

Then

$$P = \frac{2 \times (D - d) \times E}{W \times D}$$

Substitute the values which were assumed by Mr. A.:

$$P = \frac{2 \times (4.5 - 2.75) \times 13{,}500}{36 \times 4.5} = 291 \text{ pounds.}$$

Mr. B. claims that this shows that the thickness of the tube and back sheets cannot be materially reduced unless the width of the combustion chamber is decreased.

Mr. A. claims that when the girders of the crown sheet are stayed from the shell by sling stays the width of the combustion chamber has no bearing on the problem. The load, being 2,700 pounds, is resisted by the metal left between the flue hole. Therefore $(4.5 - 2.75) \times .75 \times 13{,}500 = 17{,}618.75$ pounds resistance offered by the metal between the flue holes to a force of 2,700 pounds. Therefore, the thickness of the tube sheet will depend upon the force acting upon this area, which depends upon the distance between the centers of the tubes and the size of the tubes. B. F. THROCKMORTON.

EDITOR'S NOTE:—Evidently some confusion exists in the minds of the persons who made the above claims regarding just what the compressive stress on the tube plate and back sheet is. Under the heading, "Compressive Stress on Tube Sheet," the United States Marine Laws, prescribed by the Board of Supervising Inspectors, give the formula:

$$P = \frac{(D - d)\ T \times C}{W \times D}$$

where P is the allowable steam pressure which may be safely carried on the tube sheet. The term compressive stress used in this connection is rather unfortunate. The only stresses which the steam pressure on the tube plate can produce in the plate are tension stresses, and the above formula simply gives us a means for finding the steam pressure which may be allowed on the tube plate, assuming that the tension stress in the plate must not exceed a certain value, which at the present time is made 2,700 pounds per square inch.

The only compressive stress caused in the tube sheet is that due to the steam pressure on the crown or top of the combustion chamber. With the ordinary form of girder stays not supported from the shell the steam pressure acting on the crown sheet causes a load which is transmitted by the girders and acts in a vertical direction down on the flange of the tube sheet and back sheet. If this force were applied directly over the center of the material or the center of the thickness of the tube plate, the stress would be purely compressive. As a matter of fact, however, the shape of the crown bars is such that the force is caused to act on the flange of the tube sheet, giving a case of eccentric loading. This causes in addition to the purely compressive stress on the tube sheet a bending moment, which tends to increase the compressive stress on one side of the plate and decrease it on the other.

In the case where the girders are suspended from the shell there is a much smaller force acting on the flange of the tube sheet. In this case it is equal to the force caused by the steam pressure acting on a strip of the crown sheet, which has a length equal to the width of the combustion chamber and a width equal to one-half the distance from the tube sheet to the first bolt in the girders. Moreover, as this stress is uniformly distributed over the flange of the tube sheet and not concentrated at certain points, the compressive stress per unit section in the tube sheet is very much less, and therefore the thickness of the sheet may be reduced with safety.

PERSONAL.

JOHN H. BLISS, president of the Erie City Iron Works, manufacturer of engines and boilers, Erie, Pa., died at Honolulu, Hawaiian Islands, Oct. 18, where he has been for the past five years on account of poor health. He was 84 years of age.

MR. RICHARD D. HURLEY, manager of the Pittsburg office of the Independent Pneumatic Tool Company, died in Chicago, Ill., Nov. 5, 1907, of heart trouble. He was only thirty-nine years old, and for the past ten years had been connected with the pneumatic tool business.

MR. R. E. MCNAMARA, formerly supervising inspector of steam boilers with the Casualty Company of America, has recently been appointed general boiler inspector for the United States Steel Corporation, with headquarters at the Germania Bank building, Pittsburg, Pa.

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.—Please inform me through the columns of your valuable journal how much pressure there is on an exhaust nozzle of a locomotive while working. The locomotive referred to carries 200 pounds steam pressure; the cylinders are 22 x 30, and the nozzle tip 5¼ inches in diameter.
INFORMATION.

A.—With the data given above it is impossible to give any accurate figures as to the exhaust nozzle pressure, as this is dependent on so many different things, particularly on the cut-off and speed, neither of which is mentioned by the inquirer. Henderson, in his "Locomotive Operation," gives the average back pressure, which is, of course, exhaust nozzle pressure, as 8 pounds per square inch above atmospheric pressure. In the locomotive tests conducted by the Pennsylvania Railroad system at the Louisiana Purchase Exposition the least back pressure for simple consolidation locomotive No. 734, with 21 x 30-inch cylinders and 200 pounds boiler pressure, cutting off at 26 percent of the stroke, throttle wide open, and at a speed of 30 miles per hour, was 7.3 pounds above atmospheric pressure. The size of the nozzle on this engine was 5¼ inches.

If "Information" is trying to determine whether a 5½-inch exhaust nozzle is large enough for a 22 x 30-inch cylinder with boiler pressure of 200 pounds, the writer would advise that it seems to be about the average size usual for cylinders of that diameter and stroke. E. W. S.

Q.—A small water tube boiler with up-flow pipes over the furnace, ¾ inch in diameter, and down-flow pipes, 2½ inches, has steam drum exposed to the heat and flame. Should pipes be made of iron or steel? Should the steam drum be made or iron or steel? Would malleable fittings be suitable for the return bends? The boiler is to carry 250 pounds per square inch. Durability and strength are prime requisites.
L. W.

A.—In modern high-pressure boiler construction, wrought iron pipe or plate is almost an unknown quantity. Seamless drawn steel tubes and steel plate for the drum should be employed. Malleable fittings have been used to some extent in boiler construction of this type, but for such purposes they are inferior to the so-called "homogeneous steel" castings. D.

Q.—I am in charge of two boilers of 100 horsepower each, one of which carries a pressure of 85 pounds per square inch and supplies steam for an engine; the other boiler carries a 60-pound pressure and supplies steam for dye tubs, wash vats, dry kiln, and for heating the factory. The boilers are supplied with water from one injector taking steam from the high-pressure boiler and feeding through the blow-off. Every six weeks the boilers are washed out, and we get from the low-pressure boiler nearly a pail full of mud, while the high-pressure has only a handful. Why should one accumulate more mud than the other?
W. H. C.

A.—There seems to be no plausible reason for a greater deposit of mud in the low-pressure boiler. The difference in temperature between the two is only 20 degrees, and there is no precipitation in the character of mud which would be more soluble at the higher temperature. It may be that certain other conditions not stated above enter into the question, such as a difference in circulation in the two boilers, in such a way that the mud would be deposited at different points, so that in the high-pressure boiler it may be gradually accumulating at some point which has not yet come under observation.
J. B. S.

Q.—The question came up some time ago to design a Scotch marine boiler with the following dimensions: Inside diameter of shell, 144 inches; length over all, 144 inches; working pressure, 125 pounds; longitudinal seems to be butt jointed with straps in and outside, and triple riveted; tensile strength of shell to be 60,000 pounds.

Rule for thickness of cylindrical shell according to United States inspection law:

Multiply one-sixth of the lowest tensile strength found stamped on any plate in the cylindrical shell by the thickness—expressed in inches or parts of an inch—of the thinnest plate in the same cylindrical shell, and divide by the radius or half diameter—also expressed in inches—and the result will be the pressure allowable per square inch of surface for single riveting; to which add 20 percent for double riveting, when all the rivet holes in the shell of such boiler have been "fairly drilled" and no part of such holes has been punched.

Now, 1/6 of the tensile strength for single riveting + 20 percent for double riveting is

$$1/6 + 1/6 \times \frac{20}{100} = \frac{1}{6} + \frac{20}{600} = \frac{1}{6} + \frac{1}{30} = \frac{5}{30} + \frac{1}{30} = \frac{6}{30} = \frac{1}{5}$$

Then, according to the United States rule, there would be one-fifth (1/5) of the tensile strength for double riveting.

Then a shell ¾ inch thick would be suitable for

$$\frac{60{,}000 \times 0.75}{5 \times 72} = 125 \text{ pounds.}$$

According to the inspector's figuring, this boiler would be permitted only 124 pounds, his figuring being as follows:

$$\frac{60{,}000 \times 0.75}{6 \times 72} = 104.16666666666 + . + .$$

20 percent of 104.16666666666 × 0.2 = 20.83333333333 + . + .

124.99999999999 + . + .

As the inspectors do not allow for any fraction, this boiler is allowed only 124 pounds steam pressure instead of 125 pounds, as should be mathematically, according to the United States rule.

Another way of figuring, so as to follow the United States rule exactly, is as follows:

$$\frac{60{,}000 \times 0.75}{6 \times 72} = 104\ 1/6 = 104\ \ 5/30$$

20 percent of 104 = 20 8/10 = 20 24/30
20 " " 1/6 = 1/30 = 1/30

124 30/30 = 125 pounds.

Please let me hear your opinion in this particular case. I. J.

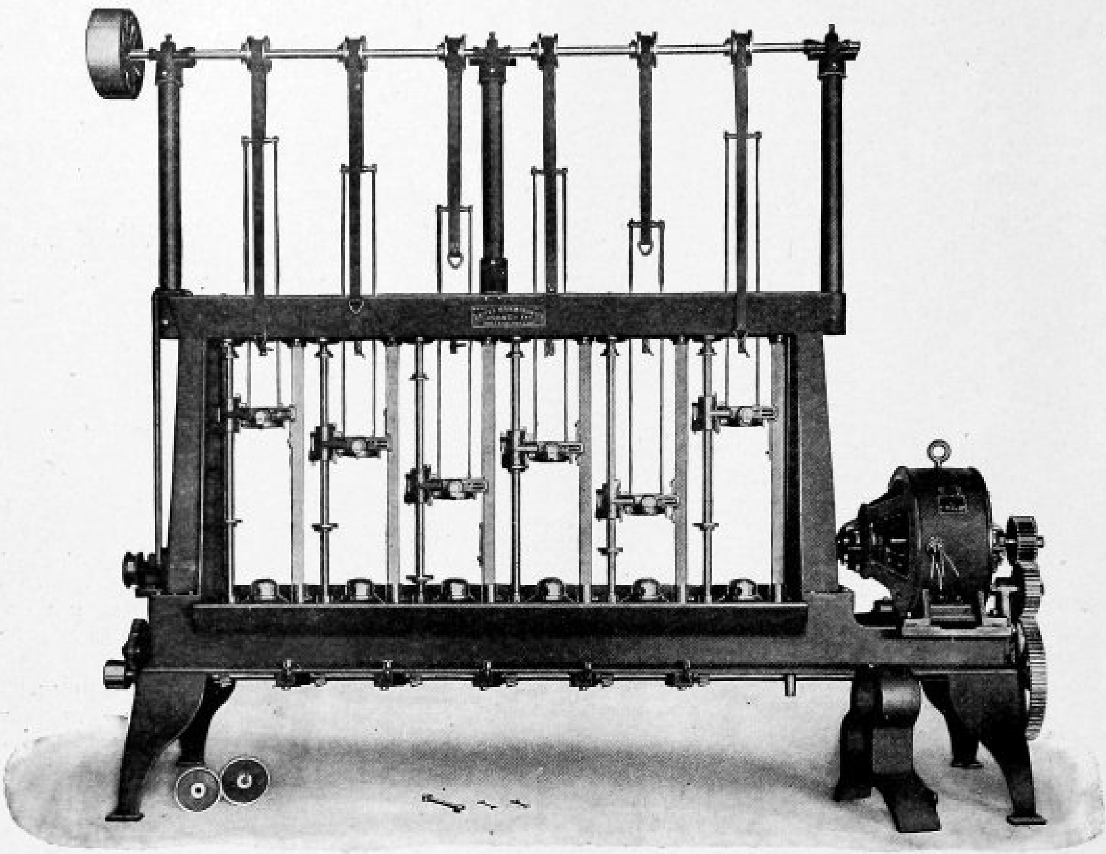
A.—The inspector who gave the figuring quoted has given another example of the sort of "pig headedness" developed by official red tape. The figuring as worked out originally, showing the boiler suitable for a pressure of 125 pounds per square inch, is absolutely correct, as is shown in the last calculation given. If a little more attention had been given by the inspector to the actual facts of the case, and a little less to the idea that the thing would have to be figured out in just one way and no other, his result would have agreed with that given by our correspondent. Again, if his decimals had been carried out to their actual limit—a proposition without possibility, and interesting only from an academic viewpoint—he would have obtained the same correct result, viz.: 125 pounds per square inch.

ENGINEERING SPECIALTIES.

Stay-bolt Threading and Reducing Machine.

Experience in railroad work has shown that boiler staybolts with reduced centers have certain advantages over the ordinary bolt which is threaded the entire length. With the center portion of the stay-bolt reduced, a smooth surface comes in contact with the water, and the strains due to expansion and contraction of the fire-box sheets have much less tendency to break off the stay. The improved Harrington machine shown in the illustration cuts the threads accurately and automatically reduces the center of stay-bolts to any desired form in one operation. This machine has six, five, four or three spindles as desired, and will thread stay-bolts of any length up to 32 inches. They can be inserted and removed while the machine is running. The capacity of the six-spindle machine at a spindle speed of 80 revolutions per minute is 225 staybolts per hour, 7½ inches long and twelve threads per inch, threaded and reduced in the center. Therefore, for a working day of 10 hours the average output would be 2,250 bolts.

The heads which carry the dies and reducing tools are each mounted on two upright guide bars. They are fed downward by lead screws to correct any inaccuracy of the threads cut by the dies. The threading dies and reducing tools are both automatically thrown in and out, and the split nut engaging the lead screw is automatically thrown open at the bottom of the cut. The head is quickly returned by a strap over a pulley lift and requires no appreciable effort by the operator. The die head has four chasers of high-speed steel, which are adjustable and of the quick opening and closing type. There are two reducing tools mounted in each head and acting oppositely to each other to prevent side strain. They are both controlled by one former, the shape of which is exactly similar to the desired reduction in the stay-bolt. It is fastened to the square guide bar by bolts in T-slots, and is adjustable the entire length. The spindles and lead screws are controlled by two horizontal shafts underneath the bed. The change feed gearing is at the outside end and easily accessible. Either belt or motor drive may be used as desired.



HARRISON STAY-BOLT THREADING AND REDUCING MACHINE.

The manufacturers are Edwin Harrington, Son & Company, Inc., Seventeenth and Callowhill streets, Philadelphia, Pa.

Special Type Allen Portable Riveter.

A special type of portable riveter has recently been designed and built by John F. Allen, 370 Gerard avenue, New York, for driving up the rivets in steam and water drum heads. Formerly work of this kind could only be done by hand unless the flange of the heads was turned outward. The class of work for which the riveter is designed, and the ingenious way in which its purpose is accomplished, is clearly shown in the illustrations. The stake of the machine is detachable and may be secured to the riveter frame proper by means of two pins. The shape of the stake is shown in the line cut (Fig. 3). Stakes, giving any desired reach or gap, can be furnished with

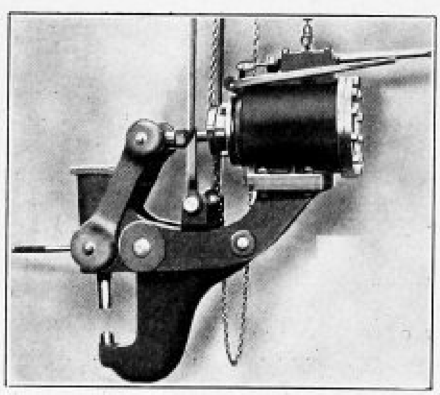


FIG. 1.—SPECIAL ALLEN RIVETER.

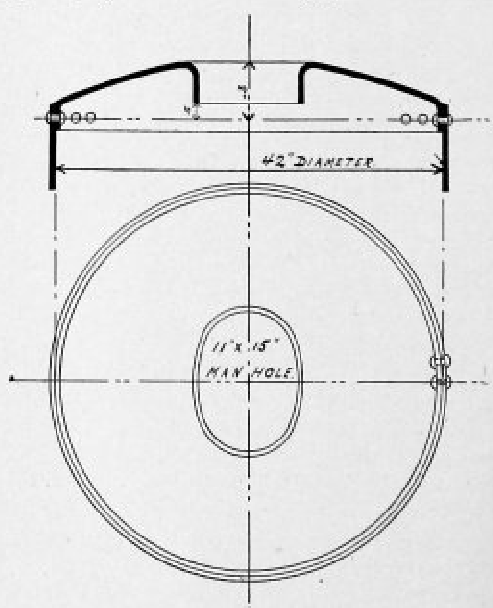


FIG. 2.—CLASS OF WORK FOR WHICH ALLEN RIVETER WAS DESIGNED.

the machine, so that heads can be riveted up in tanks of any diameter.

As shown in the line cut, Fig. 2, it is necessary to have a manhole in the head in order to operate the machine. The nose of the stake is inserted through the manhole opening.

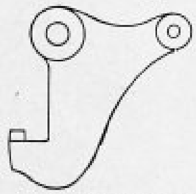


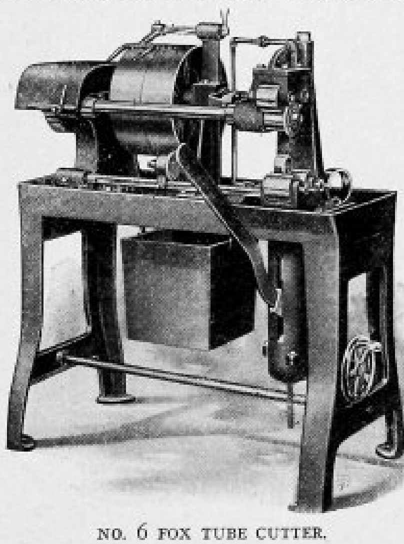
FIG. 3.—STAKE OF ALLEN RIVETER.

A die standard of the proper length to reach the rivet in the drum head is then inserted in the stake, and the riveter is held in a stationary position while the tank is revolved about it, bringing each successive rivet up to the dies.

The principal parts of the machine are all of open-hearth steel of high tensile strength, capable of withstanding the pressure of 70 tons which is exerted by this machine. The maximum capacity of the machine is 1¼-inch hot rivets.

The Fox Tube Cutter.

The No. 6 Fox heavy tube or pipe-cutting machine, manufactured by the Fox Machine Company, 542 North Front street, Grand Rapids, Mich., is particularly adapted for cutting tubing, flues, etc., rapidly. It has a capacity of from ½-inch up to 4½-inch diameter tubing. This machine is an outgrowth of preceding designs of small capacity. The earliest machines manufactured were designed for cutting bicycle tubing. This led to a demand for a machine to handle heavier stock; this in turn has led to a demand for a machine particularly suited to the requirements of boiler shops. The tube or pipe is cut by means of a circular disc, while the stock to be cut is carried



NO. 6 FOX TUBE CUTTER.

on hardened rollers. By pressing the hand lever seen in front of the machine the stock is brought in contact with the disc, which revolves continuously while the belt is on the tight pulley. As the disc strikes the stock the tube begins to rotate on the hardened rollers and is severed in a surprisingly short time. The hand wheel at the right-hand end of the machine provides an adjustment for different sizes of stock so that there may be only a short lever movement in making the cut. The shaft which carries the cutting disc operates in fixed bearings, which makes it possible to provide a very rigid construction with ample bearing surface to take care of the thrust. All the gears are accurately machine cut and are of ample dimensions. The machine is provided with an automatic pump for providing a continuous flow of oil, soda water or other lubricant. The lubricating fluid is pumped from a reservoir under the bed directly on to the cutting disc. The flow can be regulated as desired.

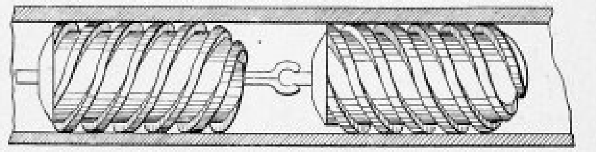
SELECTED BOILER PATENTS.

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.

864,544. PIPE AND TUBE CLEANER. Paul Kessler, of Homestead, and Theodore Stein, of Pittsburg, Penn.

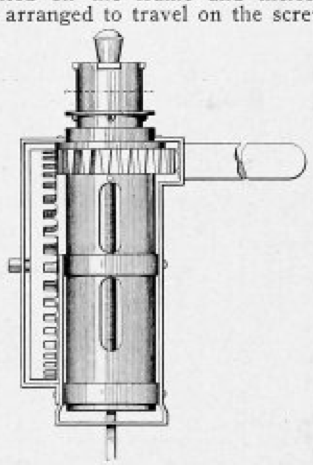
Claim.—In a tube cleaner, a rotatable cleaner-body having peripheral cutting ribs, and having a recess in one end, a plug fitted in the recess and having an axial-bore and being of less length than said recess whereby to leave a space between the inner end of the plug and the end wall of the recess, a shaft



mounted to revolve in said bore and having a head free to revolve in the space between the end of the plug and the end wall of the recess, the said shaft and head free to revolve independently of the cleaner-body and plug, antifriction balls interposed between the inner end of the plug and said head and between the head and the end wall of the recess, means within the end of the plug and surrounding the shaft for sealing the bore around said shaft, and means securing the plug to the cleaner-body whereby said plug and cleaner-body rotate in unison.

864,693. BOILER-TUBE CUTTER. Charles Roos, of Leadville, Col.

Claim.—A boiler tube cutter comprising a frame, a screw fixed against rotation relative to the frame, a cutter tube revolubly mounted on the frame and inclosing the screw, said tube being arranged to travel on the screw, the free end



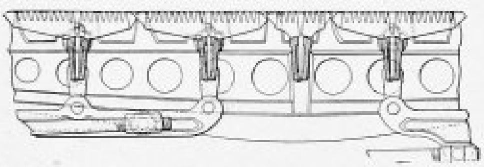
of the latter being normally arranged to project beyond the forward end of the tube, radially movable cutters upon the forward end of the tube having shanks extending therein, springs acting upon said shanks to normally retract the cutters, and a spreader mounted upon the free end of the screw for projecting the cutters in the advance movement of the tube thereon.

864,807. BOILER FEEDER. John F. Senter, of Chattanooga, Tenn., assignor to Senter Manufacturing Company, of Chattanooga, a corporation of Tennessee.

Claim. In combination with a generator, a tubular standard mounted thereon and having a pipe connected at its lower end and extending into the generator below the required level, a pair of horizontal outwardly extending tubular projections on said standard, the interior of one of said projections being in communication with the interior of the standard, a governing tank, a pipe connected to one end of said tank at the bottom thereof and provided with a horizontal portion extending into one of the tubular extensions of the standard and placing said tank in communication with the interior of said standard, a second pipe connected to the bottom of the tank, and extending upward therein to a point near the upper side thereof, said pipe being provided with a horizontal portion extending into the other tubular extension of the standard, a pipe connecting the interior of this latter tubular projection to the generator and terminating at the liquid level therein, said pipe between the standard and the generator extending above the normal water level in the governing tank and placing the interior of said tank in communication with the interior of the generator, and the pipes connecting the standard to the governing tank supporting the same and permitting said tank to have an up and down swinging movement, a lever pivoted on the standard and carrying a counter-balance weight at one end, a link connecting the shorter arm of said lever to the tank arms, a pump-controlling valve provided with a depending valve stem, a cam on the lever adapted to engage said stem, and means for normally tending to force said valve to its open position, the cam portion of the lever being adapted to close said valve when the governing tank over-balances the counter-weight on the lever. One claim.

865,929. GRATE. William McClave, of Scranton, Pa., assignor to McClave-Brooks Company, of Scranton, a corporation of Pennsylvania.

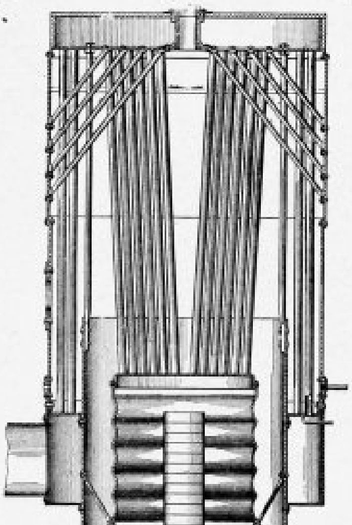
Claim.—In a grate structure, the combination with a journal bearing bar having a journal bearing and an opening leading therefrom to the edge of the bearing bar and a grate bar



journal resting on said bearing, of a cap for closing said opening, one end of said cap being retained by gravity against vertical movement, the journal bearing bar being formed with an overhanging portion projecting from the opposite side of said opening to that occupied by the gravity retained end of said cap and overhanging a portion of the cap for preventing upward movement of the journal. Twenty claims.

866,188. STEAM GENERATOR. Thomas Reed Butman, of Lake Bluff, Ill.

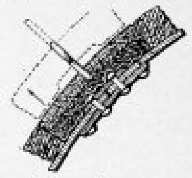
Claim.—A vertical steam boiler comprising a shell, a fire box within said shell, an open-ended annular cylinder, between said fire box and the shell extending above said fire box to provide



an annular feed-water space between said shell and cylinder, a series of fire tubes communicating with said fire box and extending through said shell, a series of return fire tubes annularly arranged and passing through said shell in the annular space provided between said shell and cylinder, and a water feed pipe communciating with said feed-water space. Ten claims.

866,235. BOILER COVERING. Edward L. Story, of Everett, Mass.

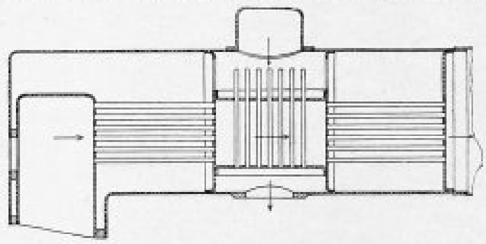
Claim.—A boiler covering having a removable section presenting a backing of wire mesh, a body portion of non-heat-conducting material applied to one side only of said backing,



and a surface coating of hard non-metallic waterproof material the edges of said backing embracing the body portion and being interlocked with said waterproof material. Five claims.

866,291. STEAM BOILER. Karl H. Merk, of Halensee, Germany.

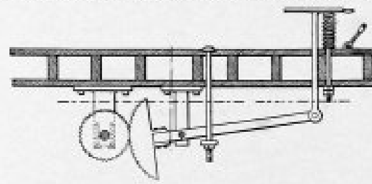
Claim.—In a steam boiler, the combination with discontinuous fire tubes, of a super-heating chamber located between the



sections of said tubes and super-heating tubes passing through and supporting and stiffening the opposite walls of said super-heating chamber. Nine claims.

866,611. FURNACE-DOOR OPENER. Floyd James Bell, of Franklin, Pa., assignor of one-half to William Ord Phipps, of Franklin.

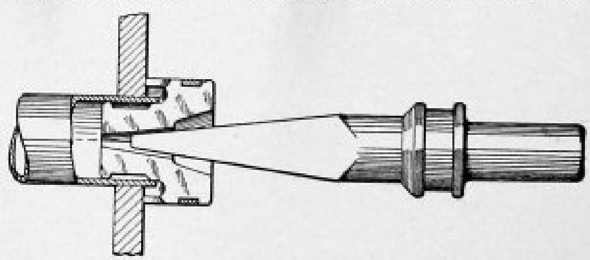
Claim.—In a mechanism of the class described, the combination with a support and a door, of a primary and an auxiliary hanger carried by said support, door-actuating means pivotally



mounted upon said primary hanger and co-operating with said door, moving the same, and means carried by said auxiliary hanger for supporting said door-actuating means when the same is not supported by said primary hanger. Eleven claims.

866,644. TUBE EXPANDER. Thomas P. Green, of St. Louis, Mo.

Claim.—A tube expander comprising a series of hollow separable sections disposed about a common central axis, said expander having a socket comprising an outer reduced taper-



ing section and an inner enlarged section, an offset or shoulder formed at the adjacent ends of said sections, in combination with a mandrel engaging the walls of the reduced section of the socket. Two claims.

867,073. CLEANER FOR WATER-TUBE BOILERS. Gilbert Patterson, of Duluth, Minn.

Claim.—The combination with a water tube boiler, of a rotatable pipe mounted within said boiler between the tubes and parallel therewith, and means for supplying the pipe with steam and rotating the same. Nine claims.