The Locomotive.

PUBLISHED BY THE

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

HARTFORD, CONN.

NEW SERIES.

Vol. XV.

HARTFORD, CONN.

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INDEX TO VOL. XV. NEW SERIES.

ARTICLES MARKED WITH A STAR (*) ARE ILLUSTRATED.

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NEW SERIES — VOL. XV. HARTFORD, CONN., JANUARY, 1894. No. 1.

The Arrangement of Returns in Heating Systems.

Among the great variety of questions submitted to us regarding the construction of boilers, the installation of steam plants, and the erection of boiler connections and piping, is one in reference to the use of check-valves in the return pipes of heating systems with gravity returns. Usually the amount of detail sent is too little to enable us to

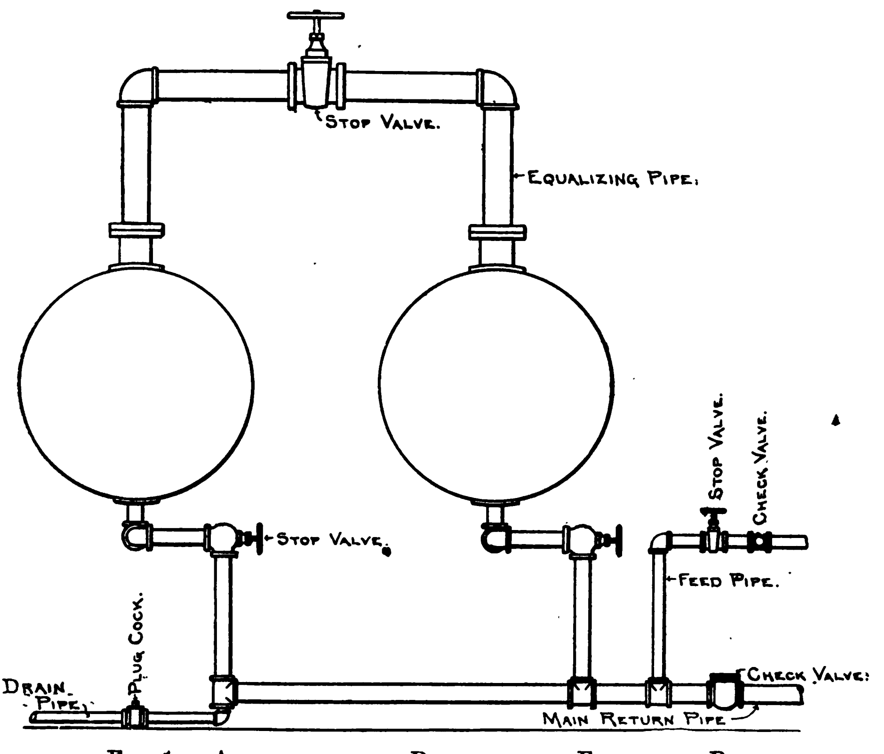

FIG. 1. — ARRANGEMENT OF RETURNS WITH EQUALIZING PIPE.

fully understand the existing condition; but, generally speaking, check-valves should be placed in the main returns near the boiler, so that should failure occur in the piping or radiators the water would not escape from the boiler.

When two or more boilers are used on the same system, and connected with the same return, there is quite a difference of opinion among engineers regarding the proper arrangement of check-valves, some contending that the individual return connections to each boiler should have separate checks, while others hold that a check in the main return, before the branch connections are taken off for the separate boilers, is all that is required; this difference of opinion being due to a corresponding difference of opinion respecting the best means of maintaining a uniform water level in all the boilers. Both of these arrangements have good points; and, on the other hand, a partisan of either of them can find objections to the other system, or, in fact, to any system not used by himself. Now, while honest discussion and criticism are proper and legitimate, it might as well be confessed that either arrangement of the checks will be found to work satisfactorily, if the system is otherwise properly designed and proportioned, and properly put together; but the "if" should be given its full emphasis, for with a check in the main return only, and with no equalizing pipe connecting the boilers, there would be great danger of the water backing out from those boilers under which there were good fires, into others having duller fires, or fires that were being cleaned, or that had been freshly coaled. Fig. 1 shows two boilers connected to a common return pipe,

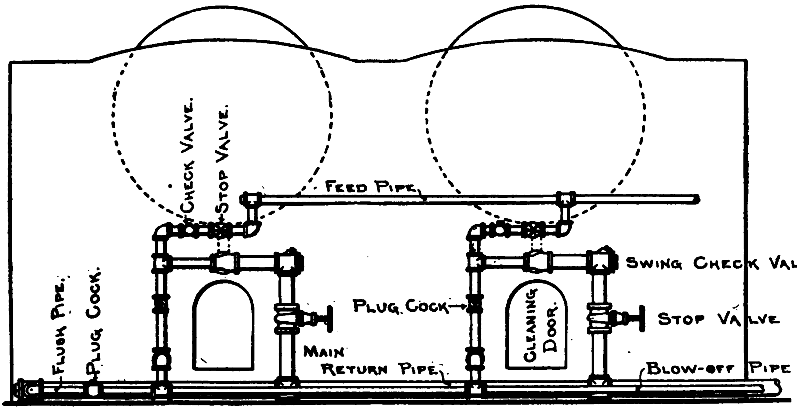

FIG. 2.—ARRANGEMENT OF RETURNS WITH SEPARATE STOP AND CHECK-VALVES.

and having an equalizing pipe between them. This equalizing pipe should be of about the same size as the main steam connections, and should not have steam drawn from it for any purpose. The equalizing pipe should be taken off from the boilers at a point as far removed as practicable from the point of exit of the main steam connection, in order that the pressure in it may be influenced as little as possible by the drafts of steam into the main steam pipe. A valve is placed in the equalizing pipe between the two boilers, to be closed *only* in case one of the boilers is out of use. When both boilers are put into service again, particular care should always be taken to open this valve first. This precaution must never be neglected.

Fig. 2 shows an arrangement of the returns, in which the branch returns to the individual boilers have each a check-valve and a stop-valve, the returns being so located that the pipes can be effectually drained when they are not in use. This latter feature is often overlooked in putting in heating plants, and consequently, when the system is not in use, water is trapped in the pipes, causing their destruction by pitting.

We have had a large experience with heating systems connected in each of the ways shown in the cuts, and with reasonable intelligence and care in the boiler room they have proved equally satisfactory.

Inspectors' Report.

OCTOBER, 1893.

During this month our inspectors made 7,272 inspection trips, visited 14,533 boilers, inspected 5,255 both internally and externally, and subjected 690 to hydrostatic pressure. The whole number of defects reported reached 9,514, of which 1,069 were considered dangerous; 44 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	738	44
Cases of incrustation and scale,	1,432	88
Cases of internal grooving,	94	23
Cases of internal corrosion,	430	29
Cases of external corrosion,	621	43
Broken and loose braces and stays,	141	21
Settings defective,	248	24
Furnaces out of shape,	342	15
Fractured plates,	295	63
Burned plates,	250	23
Blistered plates,	266	18
Cases of defective riveting,	1,228	131
Defective heads,	102	27
Serious leakage around tube ends,	1,641	268
Serious leakage at seams,	484	48
Defective water-gauges,	365	60
Defective blow-offs,	120	34
Cases of deficiency of water,	20	10
Safety-valves overloaded,	71	12
Safety-valves defective in construction,	84	44
Pressure gauges defective,	483	41
Boilers without pressure gauges,	3	3
Unclassified defects,	56	0
Total,	9,514	1,069

Boiler Explosions.

NOVEMBER, 1893.

(252.) — A 100-horse-power boiler exploded, on Nov. 1st, in the Windfall mill, operated by Summerton & Conklin, near Tipton, Ind. Lewis Null, the engineer, was killed. The boiler-house and engine-room were literally demolished, and a great deal of damage was done to the mill. One estimate places the property loss at $25,000. Clayton Summerton, Milton Cox, and Edward Fouche were more or less injured.

(253.) — A terrible boiler explosion occurred on Fourteenth street, New York city, on Nov. 2d. John Armstrong, Thomas Hasson, Samuel McMullen, William Royal, Joseph H. Quinn, Charles Breslin, and James Harlan were killed, and ten or more others received injuries more or less severe. Twenty-five horses were killed outright. The exact amount of the property loss is not known, but it was very large. (A fuller account of this explosion is given in THE LOCOMOTIVE for December, 1893, where the property loss was estimated at $40,000.)

(254.) — By a. boiler explosion in St. Louis, Mo., on Nov. 2d, George Schader, Thomas Scott, and Edward Koepke were instantly killed. The property loss was estimated at $60,000.

(255.) — A boiler exploded in Hogan's mill, in Savannah, N. Y., on Nov. 6th. Lavern Bowler was fatally injured. William Jones was within three feet of the boiler when it exploded, but escaped uninjured, save that he was made totally deaf. Several other persons had similar very narrow escapes. The building was demolished.

(256.) — On Nov. 7th a boiler exploded in the Franklin County Lumber Company's saw-mill at Carrabelle, Fla. The mill was considerably damaged, but no person was injured. The explosion was heard for a long distance.

(257.) — By a boiler explosion on Nov. 7th, at the Elrod mills, at Sand Mountain, near Birmingham, Ala., Richard Elrod and Charles Dickinson were instantly killed, and Robert Bullock and Philip Elrod were fatally injured. The mills were damaged, it is said, to the extent of $20,000.

(258.) — A boiler exploded on Nov. 10th at R. Wallace & Son's factory, at Wallingford, Conn. Several persons had very narrow escapes from death, but there were no fatalities. One man was badly scalded, however. The boiler-house was badly wrecked, and the damage amounted to about $3,000.

(259.) — A boiler exploded on Nov. 10th at the works of the American Strawboard & Paper Co., at Piqua, Ohio. The buildings and machinery were wrecked, the loss being estimated at about $18,000. The boiler crashed through three brick walls, and part of the machinery was hurled almost 200 feet in the air. Ira Grimes, John Galloway, and William Bicknell were injured ; and, as there were thirty men at work when the explosion occurred, it is remarkable that the number of injured was no greater.

(260.) — Goeleip's factory, at Kellam's, near Honesdale, Pa., was completely destroyed by a boiler explosion on Nov. 10th. Engineer Charles Kille was killed.

(261.) — A boiler exploded at Palouse, near Garfield, Wis., on Nov. 10th, killing engineer Baker, and badly injuring two other men.

(262.) — By a boiler explosion on Nov. 11th, the electric light plant in Salt Lake City, Utah, was somewhat injured. Fortunately nobody was hurt, and the damage to property was not great.

(263.) — Two large boilers exploded, on Nov. 13th, at Wentz & Co.'s colliery, near Hazelton, Pa. The boilers were blown 100 yards away, and the boiler-house, two tool-houses, and a part of the breaker, were demolished. The fireman had a narrow escape from death. Work at the colliery was suspended.

(264.) — A terrible boiler explosion occurred on Nov. 14th, at Hook's Switch, near Beaumont, Texas. The mill at that place was demolished, and Joseph Kirksy, William Weiss, and Robert McKinney were killed. Six other men were severely injured.

(265.) — On Nov. 17th, a boiler exploded at Herman Eichman's coffee-roasting establishment, in Philadelphia. The property loss was not great, but Mrs. Eichman was so badly scalded and burned that it is doubtful if she can recover.

(266.) — A boiler exploded, on Nov. 18th, in Holliday & Handley's mill, at Dixie, Ky. Harvey Minton and Cohen Minton were instantly killed. Two other men received injuries.

(267.) — On Nov. 20th, a boiler exploded at the Wisconsin Central pump-house, at Butternut, near Ashland, Wis. Fireman John Linas, and another man whose name we did not learn, were frightfully scalded, and the boiler-house was totally wrecked. There was a report that the damage was due to dynamite that had been maliciously left about the boiler. So far as we could discover, the only ground for this belief was the violence of the explosion. The individual who advanced the dynamite hypothesis had probably never seen a boiler explosion before, and found it hard to believe that steam could be so destructive in its action.

(268.) — A boiler belonging to Mr. John W. Davis, of Jerseyville, Ill., exploded on Nov. 21st. Edward Shellenberger was instantly killed, and two other men received injuries.

(269.) — On Nov. 22d, a boiler exploded at the Oshkosh Art Glass Co.'s works, at Oshkosh, Wis. Nobody was hurt, but the damage to property amounted to $15,000.

(270.) — A boiler exploded in Quincy, Mass., on Nov. 24th, and the engineer, a Mr. Helbom, was blown high in the air. It is thought that his injuries will not prove fatal. The building in which the boiler was located was blown to atoms.

(271.) — A boiler explosion occurred at James's mill, in White Ridge, near Alexandria, Va., on Nov. 24th. Albert Patterson and John W. Lee were killed instantly, and the fireman and another man were seriously burned and bruised. Mr. James, the proprietor of the mill, and a Mr. Pierson, had narrow escapes from death, timbers and portions of the boiler being blown over their heads.

(272.) — The boiler of locomotive No. 604, belonging to the Lehigh Valley railroad, exploded at North Hector, 38 miles from Sayre, Pa., on Nov. 24th. P. H. Billups, the fireman, was killed, and Engineer Cooley and Conductor Henderson were seriously, and perhaps fatally, injured.

(273.) — Richard Brooks was killed on Nov. 25th by the explosion of a boiler in Gadsden, Ala. The building in which the boiler stood was destroyed.

(274.) — A heating boiler exploded in a dwelling-house in Haverhill, Mass., on Nov. 25th. Nobody was hurt, though there were a dozen persons in the house at the time. The building was considerably damaged.

(275.) — By the explosion of a boiler at Clifton, a few miles east of Duluth, Minn., on Nov. 27th, one man was badly scalded and another was blown 100 feet and bruised to some extent. Both will recover.

(276.) — A boiler exploded in Oak Harbor, near Toledo, Ohio, on Nov. 29th, killing Edward Gordon and Edward Monroe, and fatally injuring David Wright.

(277.) — On Nov. 29th, a boiler exploded at the electric light plant in Elwood, Ind., demolishing the entire building, and seriously injuring O. B. Frazier, David Tompkins, Leonard Shively, and W. McMahon.

(278.) — A boiler belonging to Mr. George Wilks, in the town of Lake, near New Coeln, Wis., exploded on Nov. 29th. No person was injured. The damage to property amounted to about $1,000.

(279.) — A locomotive boiler exploded on the Lehigh Valley railroad, at Batavia,

N. Y., on November 29th. Daniel Connors, the engineer, was frightfully scalded from head to foot. He cannot live.

(280.) — On Nov. 30th another locomotive boiler exploded on the Lehigh Valley railroad, this time near Van Etten, a station about 25 miles from Elmira, N. Y. Charles Swartout and "Pearl" Smith were killed.

(281.) — One man was injured, on Nov. 30th, by the explosion of a boiler belonging to ex-Senator Fair, of Knight's Landing, near Woodland, Cal.

(282.) — A boiler exploded, on Nov. 30th, at Shipp's mill, Powder Springs, Ga. Evans Rakestraw was fatally injured, and Westley Rakestraw, James Ivey, and Joseph Shipp were injured seriously, but not fatally.

(283.) — One of the buildings owned by the National Distilling Co., of Milwaukee, Wis., was completely destroyed by a boiler explosion on Nov. 30th. The structure was of brick, 100 feet long, 40 feet wide, and two stories high. It was all blown down except two feet of the walls. The loss was estimated at $10,000.

A Plea for Higher Standards of Materials.

In the latest issue of *The Boiler Maker* there is an article relating to materials for boiler construction, which contains some good thoughts. We reproduce it below, for the benefit of the readers of THE LOCOMOTIVE:

"We fear our readers will tire of a higher standard of quality of material, but the need of some warning voice seems to be one of the demands of the trade. When a boiler-maker can buy his plate for less money per pound than the cost of the beams which go to make up our great buildings, is it not time to call a halt and ask the cause of it? We have inquired of manufacturers why they are making less and less high grade material every year, and we are answered, 'The boiler-makers get just what they ask for and no more.' In turn, we seek for our information from the boiler-maker, and he places the responsibility on the steam-fitter or architect, who prescribes certain physical qualities in his elaborate specifications, and there it ends. And so it seems that the modern rolling mill, costing a fortune, and in its organization embracing the highest skill and intelligence, is to be told by a steam-fitter or other maker of specifications what, and, we were about to say, how, steel plate is to be made and used. How rare is the word 'fire-box' in orders nowadays, and yet the mills are eager to make it.

"We are told that there is a larger profit in high grades of steel, and let us be thankful for that, for by this alone can the manufacturer advance his product. We maintain that the greatest injustice is done the owner of a boiler every time an inferior material is used. He would have none of it if he were given the chance to choose from something better. In the selection of an article of clothing we ask our shoemaker or tailor as to the comparative wearing qualities of his various goods. The question of varying price or durability determines our purchase. But, alas! the boiler-maker is fettered against his judgment, and has but little voice in the determination of what is a suitable article, and by force of circumstances is compelled to look at price alone. The emancipation of the boiler-maker is one of the needs of our trade.

"The terms 'Bessemer' and 'open-hearth' steels, have reference to methods or processes and not necessarily to qualities. If a good quality of pig-iron is made into steel by either the Bessemer or open-hearth process, it would be found that the latter was softer and more uniform under the stress of severe usage. But Bessemer steel made of good iron is better than open-hearth steel made of a cheap and inferior material. Therefore the Bessemer tank steel of some manufacturers will run better than the open-hearth flange steel of other makers. The name dosn't make the reality."

We have received from the Yorkshire Boiler Insurance and Steam Users' Company, limited, a copy of a report made by Mr. John Waugh to the coroner of the southern division of Leicestershire, Eng., relative to the boiler that exploded on October 25th at Red Hill Quarry, Narborough. The boiler was upright, 9 ft. 8 in. high and 4 ft. 0 in. in diameter. The fire-box was 3 ft. 6 in. in diameter, 5 ft. 8 in. high. It was composed of three plates, ⅜ in. thick, with vertical seams, and was strengthened with four cross-tubes. The explosion occurred about an hour and a half after the boiler was fired up. A portion of the fire-box was blown out, and the boiler was blown 420 feet from its original place. It was insured by the Manchester company for a pressure of 60 pounds per square inch. Mr. Waugh reports that at the time of explosion it was strong enough to bear the stipulated pressure safely, and he also says that there were no signs of overheating from shortness of water. He concludes that the explosion was caused by simple overpressure. The safety-valve seems to have been unfit for the work it had to do. The valve was not the one originally supplied with the seating, and in order to make the valve fit the seating a "liner" had been put around the "wings" of the valve. The effect of this was to reduce the area of discharge to about one-half of one square inch. Moreover, the proportions of the valve were such that if the ball were at the end of the lever the valve would not rise till the pressure reached 118 pounds, which is practically double what the boiler was allowed to carry. The coroner's jury returned a verdict in accordance with Mr. Waugh's report, and they also blamed the owners of the boiler for not looking after its working condition more sharply. Mr. Waugh's report is illustrated by three plates which give a good idea of the boiler and the safety-valve.

The San Francisco papers have had considerable to say about the boilers in the basement of the City Hall in that place. If all that is said about them is true, they must be extraordinary boilers indeed. One man said he could "take a tack and press it through some parts of them." Another says that "two of the boilers were beyond all repair. They had been patched and were full of holes. A lighted candle could be seen when placed in the interior of the boilers."

Why were these boilers not exhibited at Chicago?

A writer in *Locomotive Engineering* tells of an imposing report made by a locomotive engineer who failed to keep a proper supply of water in his boiler. The crown-sheet was overheated, and extensive repairs were required. The report was as follows: "Owing to a temporary deficiency of dampness on the roof of the furnace of engine 76, the active combustion of carbon produced caloric intensity sufficient to permanently derange the contour of the sheet, suspend active participation of this locomotive in the transportation department, and require the employment of skilled artisans and mechanical appliances unattainable at the time and place of such unsolicited and unexpected derangement of crown-sheet and schedule, caused by procrastination in the application of appliances for the introduction of water to the interior of the boiler."

The Locomotive.

HARTFORD, JANUARY 15, 1894.

J. M. ALLEN, *Editor*. A. D. RISTEEN, *Associate Editor*.

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

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Bound volumes one dollar each. (*Any volume can be supplied.*)

Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

WE desire to acknowledge the receipt from Chief Engineer Guido Perelli of the *Reports* for 1891 and 1892 of the Milan Associazione fra gli Utenti di Caldaie a Vapore.

SOME time ago we had the pleasure of noticing in these pages Mr. Simpson Bolland's *Iron Founder*, and now we have received from Messrs. John Wiley & Sons, of 53 East Tenth street, New York, a copy of another work by the same author. Mr. Bolland calls his new book *The Iron Founder Supplement*, but as it contains about 400 pages and 200 illustrations it would seem as though it were entitled to a more pretentious name. We have read it with considerable profit, and we can commend it to any one interested in iron founding or any of the branches of industry connected therewith.

THE Builders Iron Foundry of Providence, R. I., has favored us with an interesting pamphlet on *The Venturi Meter*, an instrument (if one may call it so) for measuring the flow of water through pipes. It is certainly a unique device. The water does not flow through any measuring apparatus at all, in the ordinary sense of the word. The indications of the meter depend on the general principles of hydraulics pointed out by the Italian philosopher Venturi in 1796; that is, on the "relation between the velocities and pressures of fluids when flowing through converging and diverging pipes."

The Paris Exposition.—Report of the U. S. Commissioners.

We have received from Gen. Wm. B. Franklin, Commissioner-General for the United States, and Vice-President of the Hartford Steam Boiler Inspection and Insurance Company, a copy of the *Reports of the United States Commissioners to the Universal Exposition of 1889*, at Paris. It consists of five volumes. Of these, the first contains the report of the Commissioner-General, with accompanying documents, including reports of officers of the commission, official regulations, classification, and lists of exhibitors and of awards. The second volume contains the reports on the fine arts, on education and the liberal arts, on furniture, textile fabrics, and wearing apparel, on the extractive arts and raw and manufactured products, and on hygiene. The third volume gives the reports on apparatus and processes of mechanical industries and civil engineering. The fourth volume contains the reports on electricity, on military and life-saving material, on alimentary products, and on horticulture; and the fifth and final volume is devoted to agriculture and allied subjects.

We should be pleased to review this most interesting report very fully; but as it contains, in all, over four thousand pages, it will be impossible to give more than a superficial account of it. In his report in the first volume, Gen. Franklin pays a high tribute to the juries that had the task of passing upon the merits of the exhibits. "They worked steadily at all available hours," he says, "until everything exhibited for competition was examined. I have never seen such honest, conscientious hard work as was done by this large number of distinguished men, who served without pay. Their reward was the appreciation by their countrymen and foreign exhibitors of their disinterested labors, and the consciousness — which they have a right to hold — that no body of men ever performed a delicate and laborious task with more industry, with greater ability, and with a better sense of justice to all." We also learn from this report that the number of recompenses of all degrees awarded during the exposition was 33,138. This includes 903 grand prizes, 5,153 gold medals, 9,600 silver medals, 9,323 bronze medals, and 8,070 diplomas of honorable mention. In addition to these, 5,500 medals of various kinds "were awarded to collaborators, workmen who were noted for skill and ability and faithfulness in the work-shops in which the exhibits were prepared." (There were over 60,000 exhibitors in all.) Of these awards, over a thousand were granted to exhibitors from the United States, the awards to this country's exhibits being as follows: Grand prizes, 55; gold medals, 214; silver medals, 300; bronze medals, 246; diplomas of honorable mention, 229. Gen. Franklin, commenting on this list of awards, says: "The United States fared better than any other foreign nation in the number and nature of the awards granted to its exhibitors." He also states that the French estimate of the number of people from the United States that visited Paris during the Exposition is 90,000. It will readily be imagined that multitudes of difficult points were continually coming up before the commission in the discharge of their duties, and that it was an almost impossible task to meet and decide them with the necessary promptness and fairness to all concerned; and one who is in any way familiar with these things will appreciate the following passage from Gen. Franklin's report: "I was well assisted by my subordinates in conducting the business of the commission. As a rule, persons connected with a United States commission to a foreign exposition have no experience in international expositions, and the business is entirely new to them, and requires a certain apprenticeship. By the time the business is learned the exposition is over, and the employes scatter, usually declaring that they will never belong in any capacity to another exposition. The United States commission was no exception to this rule. The business was new to all connected with it, except two or three persons, but it went on as well as that of the other foreign commissioners, and I think creditably to the United States." From the report of Chief Engineer Gunnell we learn that the area covered by Machinery Hall was 654,550 square feet, and that the area covered by the Palace of Liberal Arts was 202,826 square feet. The total floor space occupied by the United States was 113,300 square feet. There are numerous interesting appendices to Gen. Franklin's report, replete with statistical and other information; and the first volume concludes with a very full and complete index, which adds immensely to the value of the report, and to the convenience of the reader. There are also twenty-two excellent engravings.

The second volume of the Report begins with the report on the Fine Arts. We note, on page 19, a vigorous onslaught on the "Angelus," with which we heartily sympathize; but as we know more about boilers than we do about art, it may be that our opinion in this matter is of no great importance. The "Angelus" is a fine painting, but we have seen many that we liked better. The report is illustrated by about a dozen engravings of paintings and statuary, most of which are excellent. The representation of the "Nymph Echo" is particularly good. Fremiet's "Gorilla and Woman," though it could hardly be called beautiful, is, nevertheless, a powerful and well executed work; and the engraving of it that accompanies the report is very good. Following the report just considered are the reports on Education and the Liberal Arts. It is almost impossible to give any adequate idea of these reports. Prof. Hastings's essay on "Optical Instruments and Optical Materials" is very fine, and no one interested in these subjects should fail to read it. The reports on Furniture and Accessories are very good and complete. In the report on the Products of Mining and Metallurgy there is an account of the manufacture of sodium, which is of considerable interest. The estimated expense of producing this metal by the Castner process is 10½ pence per pound, or about 21 cents. (It is interesting to note, in this connection, that the market price of sodium has recently risen from about 75 cents per pound to $1.75. This is not due to any fault in the process of manufacture. It probably results from a diminished demand for the metal, owing to the fact that aluminium, in the extraction of which it was chiefly employed, is now produced by other means.) In the report on Chemicals and Pharmaceutical Products there is an account of Chardonnet's process for the manufacture of artificial silk. (See THE LOCOMOTIVE for 1893, p. 63.) It appears that the fiber produced by this process can be easily dyed, and that its most objectionable feature (its inflammability) can be overcome by immersing the skeins in dilute nitric acid. It is said that specimens of fabric woven from the artificial silk appear to be "fully equal to true silk in luster and softness." This volume (Vol. 2) contains 141 excellent plates.

The third volume of the Report relates to the apparatus and processes of the mechanical industries, and to railways, civil engineering, public works, and architecture. It is illustrated with 22 plates, and about 300 cuts in the text. In the early part of this volume we read that in the machinery at the Exposition "few absolutely original ideas are to be found. The machinery and apparatus exhibited are little more than recombinations of principles already well-known and applied. Not only would we seek in vain in the vast buildings for some one of those great discoveries which change the character of an industry, but even, in a far more limited sense, inventions which possess a moderately important scope are absolutely wanting. . . . The machines exhibited are, as a whole, better designed and more intelligently combined than those shown in the former expositions; their proportions are better, their workmanship more perfect. In fact, considerable advance has been made. But it is not by great inventions that this progress has been effected; it is rather by a thousand improvements which relate to the details of the machinery." It is gratifying to read, further on, that "no part of Machinery Hall was examined with greater approval by European engineers than was the United States section. The general verdict of these men was that the greater proportion of those machines in which freshness and originality were shown was to be found in this section, and that here the interesting new idea and useful invention were conspicuous above the uniform grade of general excellence everywhere found in the mechanical exhibits." The Commissioner subsequently says that "the representation of the United States was by no means, however, confined to its own section; its proudest display was, in fact, seen outside of the actual exhibits made by its own citizens. Much of the machinery exhibited by the other nations was either admitted to be of design belonging to the United States, and advertised to be this, or else was a close imitation of forms which have originated with its engineers and inventors." Numerous examples of this are given. The reports on mining and metallurgy, on machine tools, on knitting machinery, and on brick and tile machinery cannot be noticed here, further than to say that they are well worth perusal. The special report on railway plant occupies over 100 pages, and is illustrated by numerous cuts and engravings. In it we notice a reference to the fireless locomotives constructed by the Continental Company of Paris. They are charged with hot water at a temperature of 392° Fah., and they are propelled by the steam this body of water can give off before cooling to 212°. We learn that these locomotives "have been in successful operation for eight years in the Indies, Netherlands, France, England, Austria, and the United States." It would be interesting to know how far they will run before requiring recharging. The report on civil engineering is one of the finest and most extensive of all, and is beautifully illustrated with photo-engravings and wood-cuts.

The fourth volume begins with the report on electricity, in which the many marvelous inventions in this field are described. The accounts of duplex, quadruplex, and multiplex telegraphic systems, by means of which several messages may be sent over the same wire, simultaneously and in both directions, without confusion, will be found interesting to those who do not understand these curious and wonderful applications of electrical principles. The general tendency of the age seems to be to do *everything* by electricity; and it would be impossible to even enumerate the things described and discussed in the report. The report on Military and Life-saving Material comes next in order. It is very comprehensive and very creditable. It is illustrated with about seventy full-page engravings and folding plates. The remainder of this volume consists of the reports on Alimentary Products and on Horticulture. The report on Alimentary Products occupies more than 700 pages, and in it almost every conceivable kind of food material is discussed. It would be rare reading for an epicure seeking for "pointers" about new things to eat.

The fifth volume of the report is devoted exclusively to agriculture and allied subjects, and is replete with interesting and useful information.

In concluding this necessarily imperfect notice of the Report of the United States Commissioners, we must express our appreciation of the enormous amount of hard work its preparation has entailed on General Franklin and his colleagues. They may feel amply repaid for the labor, however, for they have produced a report that surely is not excelled by anything of the kind that has been published in the past. The commissioners to the Columbian Exposition will need to exert themselves to the utmost to come up to the standard these gentlemen have set for them.

The Properties of Steam.

In the issue of THE LOCOMOTIVE for April, 1880, we published a table of the properties of steam, which was based upon what were then the standard authorities on the subject. Since that time other standard works have appeared, and we have thought it well to re-publish the table, after making such changes as would be required to bring it into conformity with the best practice of to-day. The changes are, for the most part, slight and unimportant, and would probably not be appreciable in practical work. The present table, however, is believed to be a little closer to the actual facts than the one published in 1880.

The first and last columns give the pressure of the steam in pounds per square inch, as read by the gauge. It is often assumed, in the construction of tables of this kind, that the pressure as read by the gauge is an even 15 pounds greater than the "absolute pressure." In preparing the present table, however, we have used the more exact value of 14.69 pounds; which is the same as saying that the "gauge pressure" is 14.69

pounds greater than the "absolute pressure." This will vary, of course, with the height of the barometer; but for all ordinary purposes it is not necessary to take account of the barometer, the average pressure being quite accurate enough except in certain refined tests where the utmost accuracy is demanded. Assuming the average pressure of the air to be 14.69 pounds per square inch is the same thing as assuming the average height of the barometer to be 29.95 inches.

The second column needs no especial explanation. It gives the temperatures, on the Fahrenheit scale, corresponding to the pressures in Column 1.

The third column gives the number of cubic feet of steam, at any given pressure, that are obtained when one cubic foot of water (measured at 60° Fah.), is evaporated at the various pressures given in the first column. Since water expands comparatively little when it is heated, this column, for practical purposes, may be considered to give the number of cubic feet of steam produced by each cubic foot of water, whatever the temperature at which the water is measured. In calculating this column, the weight of a cubic foot of water at 60° Fah. has been taken to be 62.367 pounds.

The fourth column gives the weight of one cubic foot of steam at the different pressures, and the fifth column gives the number of cubic feet of steam that weigh one pound.

The sixth column gives the amount of heat required to change a pound of water, at any given temperature, into a pound of steam at the same temperature; and the seventh column gives the total amount of heat that is required to change a pound of water at 32° Fah. into a pound of steam at any given pressure. The "heat unit" referred to, is the amount of heat required to raise the temperature of a pound of water one degree. This is not precisely the same for all temperatures, though it is nearly so, and in most cases it is customary to consider it constant for all temperatures. In the present table the "unit of heat" means the amount of heat required to raise the temperature of a pound of water from 32° Fah. to 33° Fah.

It may be well to illustrate the use of the table by a few examples. Thus, suppose we wished to know how many cubic feet of steam at 85 lbs. pressure would be obtained from 6 cubic feet of water. The table gives 273 as the number of cubic feet of steam from one cubic foot of water. Hence we have $6 \times 273 = 1,638$ cubic feet, the answer required. Again, suppose we wished to know how much 40 cubic feet of steam at 120 lbs. pressure would weigh. The table gives .304 of a lb. as the weight of one cubic foot, and hence 40 cubic feet would weigh $40 \times .304 = 12.16$ pounds. If we wanted to know how many cubic feet of steam at 70 lbs. pressure it would take to weigh 100 pounds, we find in the table that it would take 5.09 cubic feet to weigh one pound; and therefore we know that it would take $100 \times 5.09 = 509$ cubic feet to weigh 100 lbs. This would just about fill a cubical box that is 8 feet each way; and yet it must not be supposed that such a box would seem to weigh 100 pounds if it were tried on scales. Such a box, when filled with steam at 70 pounds, would weigh 100 pounds more than it would when it was entirely empty—that is, it would weigh 100 pounds more than it would when it contained neither steam *nor air*. Air buoys up substances that are immersed in it, just as water does; except that it does not buoy them up to the same degree, because it is not so dense as water. A cubic foot of air, under ordinary conditions of temperature and pressure (that is, at 60° Fah. and 14.69 pounds pressure to the square inch) weighs .07634 of a pound; and, conversely, under the same circumstances it takes 13.099 cubic feet of air to weigh a pound. Referring back, therefore, to the first part of the paragraph, we find that the *actual* weight of 40 cubic feet of steam at 120 lbs. pressure is 12.16 pounds. If we wished to

THE PROPERTIES OF STEAM.

Pressure of steam.	Temperature. (Fah.)	Volume and Weight. Cubic feet of steam from one cubic foot of water.	Weight of one cubic foot of steam.	Cubic feet of steam to the pound.	Heat. Latent heat in one pound of steam.	Total heat above 32° in one pound of steam.	Pressure of steam.
Gauge.	Thermometer.	Cubic Feet.	Pounds.	Cubic Feet.	Heat Units.	Heat Units.	Gauge.
1	2	3	4	5	6	7	8
0	212°	1645	.0379	26.38	966.1	1146.6	0
5	227	1249	.0499	20.03	955.4	1151.2	5
10	239	1010	.0618	16.19	946.8	1154.9	10
15	250	849	.0734	13.62	939.4	1158.1	15
20	259	734	.0850	11.77	933.1	1160.8	20
25	267	647	.0964	10.37	927.4	1163.3	25
30	274	579	.1078	9.28	922.2	1165.5	30
35	281	524	.1190	8.40	917.5	1167.5	35
40	287	478	.1304	7.67	912.7	1169.4	40
45	292	441	.1414	7.07	909.2	1171.1	45
50	298	409	.1524	6.56	905.4	1172.7	50
55	302	381	.164	6.11	901.8	1174.2	55
60	307	357	.175	5.73	898.5	1175.6	60
65	312	336	.186	5.39	895.3	1177.0	65
70	316	317	.196	5.09	892.3	1178.3	70
75	320	301	.207	4.83	889.3	1179.5	75
80	324	286	.218	4.58	886.6	1180.7	80
85	327	273	.229	4.37	883.9	1181.8	85
90	331	260	.240	4.17	881.4	1182.9	90
95	334	249	.251	3.99	878.9	1183.9	95
100	338	238	.261	3.83	876.5	1184.9	100
105	341	230	.272	3.68	874.2	1185.9	105
110	344	221	.282	3.54	872.0	1186.8	110
115	347	213	.293	3.41	869.8	1187.8	115
120	350	205	.304	3.29	867.7	1188.7	120
125	353	198	.314	3.18	865.7	1189.5	125
130	355	192	.325	3.08	863.7	1190.3	130
135	358	186	.336	2.98	861.8	1191.2	135
140	361	180	.346	2.89	859.9	1192.0	140
145	363	175	.356	2.81	858.0	1192.7	145
150	366	170	.366	2.73	856.2	1193.5	150
155	368	165	.377	2.65	854.5	1194.2	155
160	370	161	.388	2.58	852.8	1194.9	160
165	373	157	.398	2.51	851.1	1195.6	165
170	375	153	.408	2.45	849.4	1196.3	170
175	377	149	.418	2.39	847.8	1197.0	175
180	379	145	.429	2.33	846.2	1197.6	180
185	382	142	.441	2.27	844.7	1198.3	185
190	384	138	.450	2.22	843.1	1198.9	190
195	386	136	.459	2.18	841.6	1199.6	195
200	388	133	.467	2.14	840.1	1200.2	200

know the *apparent* weight of this steam we should have to subtract from the actual weight (12.16 pounds) the weight of an equal volume of air. Now since one cubic foot of air weighs .07634 of a pound, it is evident that 40 cubic feet of it will weigh 40 × .07634 = 3.0536 pounds. Calling this, in round numbers, 3.05, we have, as the *apparent* weight of 40 cubic feet of steam at 120 lbs. pressure, 12.16 – 3.05 = 9.11 pounds; which is the weight of the steam as we should obtain it by weighing it in air, on a pair of scales.

We see from the table that up to 15 pounds pressure, or thereabouts, steam is lighter than air; and, consequently, it is not possible for steam of less pressure than this to have any *apparent* weight. At higher pressures steam is denser than air, and its apparent weight can be readily found. Thus to take the same example as before, let us find how many cubic feet of steam, at 70 lbs. pressure, it would take to *apparently* weigh 100 pounds. The *true* weight of one cubic foot of such steam is .196 of a pound, and subtracting from this .076, the true weight of one cubic foot of air, we find that the *apparent* weight of a cubic foot of steam at 70 lbs. is .196 – .076 = .120 of a pound, and therefore, to have 100 pounds apparent weight, it would take 100 ÷ .120 = 833.3 cubic feet of the steam. This calculation is easily verified; for the absolute weight of 833.3 cubic feet of steam at 70 lbs. is 833.3 × .196 = 163.3 pounds, and the absolute weight of the same volume of air is 833.3 × .076 = 63.3; and therefore the *apparent* weight of the steam is 163.3 – 63.3 = 100 pounds, which verifies the calculation.

To illustrate the use of Column 6, let us suppose that it is required to calculate the amount of heat that ten pounds of steam at 40 lbs. pressure will give out, by merely condensing to water, and without subsequent cooling. (This sort of condensation takes place in steam pipes, the water of condensation remaining at the same temperature as the steam around it.) We find from the table that one pound of steam, under the circumstances, would give out 912.7 heat units. Ten pounds, therefore, would give out 10 × 912.7 = 9,127 heat units.

If it were required to find the quantity of heat that would be required to transform 12 pounds of water at 46° Fah. into 12 pounds of steam at 110 lbs. pressure to the square inch, we should use Column 7. It appears that 1,186.8 heat units would be required to convert one pound of water at 32° into one pound of steam at 110 lbs. pressure; but as the given feed-water is *already* 14° above 32°, we should need 14 heat units less than the tabular amount of heat; so that the number of heat units required to transform a pound of water at 46° into a pound of steam at 110 lbs. pressure would be 1,186.8 – 14 = 1,172.8. To evaporate 12 pounds under these conditions we should therefore need 12 × 1,172.8 = 14,073.6 heat units.

As a final example in the use of the table, let us find out what is the greatest amount of water that one pound of coal can evaporate, the feed water being at 100° and the steam pressure 70 lbs. The feed water being 100° – 32° = 68° above the freezing point, the number of heat units required for each pound of water is 1,178.3 – 68 = 1,110.3. Now a pound of pure carbon, upon undergoing complete combustion, gives out 14,000 heat units; and if we assume the coal to consist of pure carbon, we find that one pound of it could evaporate 14,000 ÷ 1,110.3 = 12.61 pounds of water, under the specified conditions, provided all of its heat could be made available. Of course, no coal consists of pure carbon, and no boiler utilizes all the heat produced under it. We should therefore regard 12.61 pounds merely as a limit that it is not possible to exceed.

THE January issue of *Cassier's Magazine* is of unusual interest and excellence, and it might even be described as an art publication, except that the field of the magazine is engineering. There are, in this issue, for instance, fifteen tinted portraits of distinguished engineers, and over sixty other fine illustrations, most of which are half-tone engravings from photographs, or from what engravers call "wash drawings." But the excellence of the present issue is not by any means confined to the illustrations. There are interesting articles on timely subjects by Messrs. Jackson, Trautwine, Randolph, Leavitt, Emery, Webber, Hutton, Henderson, Cole, Blackwell, Wiley, Thompson, Spies, and Coxe, besides the usual notes on "Current Topics." The issue is decidedly creditable to both editors and publishers.

THERE were many strange things on exhibition at the World's Fair, and there was one in particular that seemed so impossible that many visitors would not believe in its reality, and came away with the impression that they had seen a clever feat of legerdemain; whereas the fact is it was a genuine natural phenomenon, which will doubtless be put to use in the arts. We refer to the experiment shown in the electrical building, where a bar of iron was raised to a welding heat by plunging it into a bucket of water. Several persons have asked our opinion of this astonishing performance, and perhaps an explanation of it would be interesting.

Most of our readers know that water is composed of two substances — oxygen and hydrogen — which are both gaseous when they exist separately, but which condense and produce that familiar liquid when they are united chemically. This may be proved by mixing one volume of oxygen with two volumes of hydrogen, and applying a light to the mixture. It explodes violently, and for this reason the experiment must be performed in a strong vessel. When proper precautions are taken, it is found that there is nothing in the vessel after the explosion but water and steam. The original gases have entirely disappeared, and the new substance (*i.e.*, the water) does not bear the slightest resemblance to either of them.

The composition of water may also be proved by *analysis*. For example, if the two terminal wires of a galvanic battery be dipped into a glass of water, it will be found that bubbles of gas are given off at the negative wire (*i. e.*, the one connected with the zinc end of the battery), and if these bubbles are collected, they will be found to consist of hydrogen. If the positive wire is of platinum, or gold, or some other non-oxidizable metal, bubbles of gas will appear there, too; and upon collecting them we shall find that they consist of oxygen. (If the positive wire is copper, the oxygen bubbles will not be obtained, for the oxygen will unite with the copper as fast as it is liberated, forming oxide of copper.)

In the experiment referred to above, the bar of iron was connected to the negative pole of a powerful dynamo, the other pole of which was connected with the bucket, or with a plate of copper in the bottom of it. The water in the bucket immediately began to decompose, and hydrogen was deposited all over the submerged surface of the iron bar. In a few moments the bar became covered with a film of hydrogen that protected it from contact with the water around it. If the dynamo were not very powerful, the electric current would then cease to flow, because the continuity of the circuit was broken. But as the experiment was arranged at the Fair, the dynamo was so powerful that it overcame the great resistance of the film of hydrogen, and sent its current right through it. Now it is a general fact that heat is produced wherever an electric current encounters a resistance — just as heat is produced in the bearings of an engine when the journal resists the motion of the shaft owing to roughness or grit or bad alignment. Hence the electric current from the dynamo generated great heat in passing through the resistant film of hydrogen that was deposited on the surface of the iron bar; and the dynamo used in the experiment was so powerful that it could produce heat enough to make the bar white-hot in a few moments. The water did not quench the bar, because the hydrogen film prevented the two from coming into actual contact with each other.

It was a remarkable and instructive experiment, and will never be forgotten by those who saw it performed.

The Locomotive.

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Through Bracing.

In discussing the bracing of boiler heads in previous issues of THE LOCOMOTIVE, we have shown different forms of radial braces, including both the crow-foot, or solid brace, and braces attached to tee-irons, and so placed as to run back to the shell in a direct line from the head fastening, at a proper angle. In the present issue we show a form of "through bracing," in which the braces run from head to head. This type of

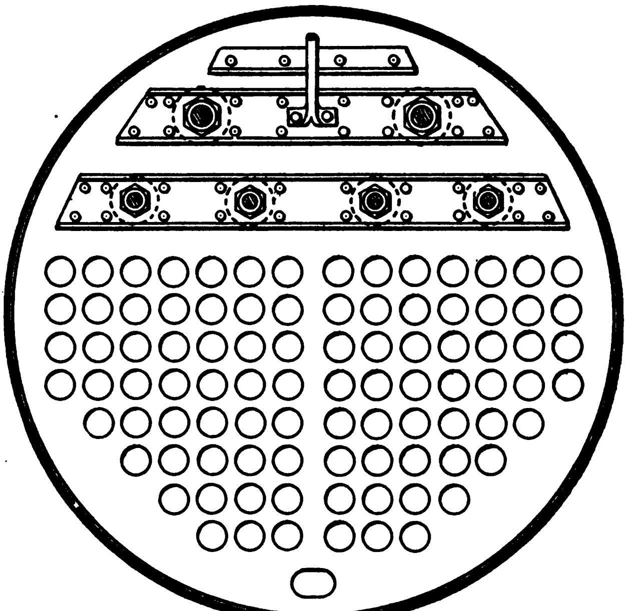

FIG. 1. — A BOILER HEAD WITH THROUGH BRACES.

bracing is in use by several of our large builders of boilers, and with proper design and care in the details of construction, it can be made perfectly tight, and sufficiently strong for the support of the flat surfaces.

In designing these through braces, however, there are important points that must not be overlooked. For example, it is very easy to find a distribution of the braces which would give the same load on each one of them, and also amply stay the heads; but which, nevertheless, would cut off all access to the boiler, and seriously interfere with making inspections or repairs. The problem of allowing access to the boiler, and still proportioning the bracing so that each brace shall sustain its equable share of the load, may be solved by riveting steel channels to the heads, to serve as washers, or stiffeners, and passing the braces through them, as shown in the illustrations. The braces should be of the best iron, without weld, and should be upset for a distance of six or eight inches from the ends, so that when these ends are threaded the diameter at the bottom of the thread shall slightly exceed the diameter of the main body of the brace. The hole through the head and the channel bars is of such a size as to just admit the enlarged end of the brace, and each brace is secured by a lock nut inside, and a close-

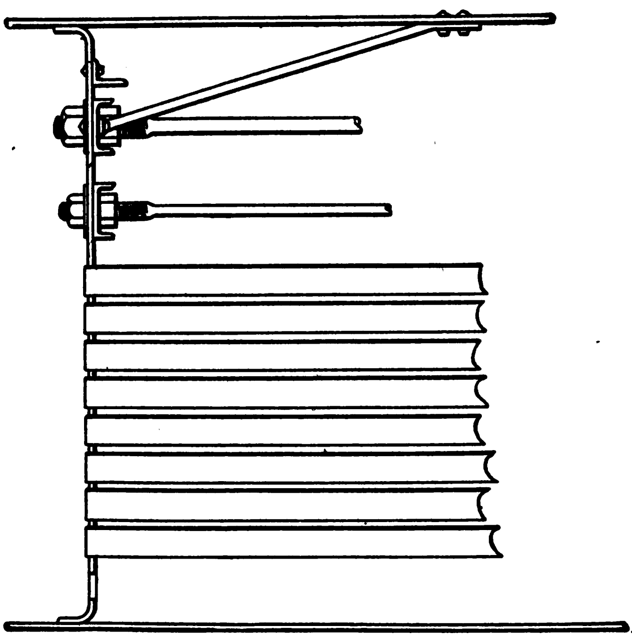

FIG. 2. — SIDE VIEW OF A BOILER HEAD WITH THROUGH BRACES.

fitting copper ring washer and nut on the outside. With proper care in the fitting, a tight joint can be made in this manner, and the head will be held firmly in its natural position.

Six-inch channel-bars are commonly used when bracing is arranged in this manner; but the tendency of the head to buckle between supports is controlled by the spacing of the *rivets*, and we find that a larger channel-bar gives a more equable distribution of the rivets, and consequently a more uniform support to the head.

In this kind of bracing, the number of braces is limited; while with radial bracing the number can be increased to any desired extent. With radial bracing greater strength is obtained by increasing the *number* of the braces. With through braces, on the other hand, increased pressure is provided for by an increase in the *size* of the braces. This is an important consideration; for braces that at 100 pounds pressure sustain a stress of 7,500 pounds per square inch, would not be proper if the boiler were to carry 125 or 150 pounds. The braces should always be proportioned to the surface they have to sustain, and to the pressure of the steam. It may seem needless to refer to so obvious a fact as this, but our experience has shown that too little attention is sometimes paid to it, and hence we feel called upon to urge its importance.

We shall shortly return to this subject of through bracing.

Boiler Explosions.

DECEMBER, 1893.

(284.) — A boiler exploded in Gallipolis, Ohio, on December 1st, seriously scalding Charles Naul, and breaking his leg. Engineer Charles Clark was also scalded. The boiler was blown over Supt. Rutter's residence.

(285.) — A boiler exploded in Marinette, Wis., on December 2d. The damage was small.

(286.) — On December 3d a boiler exploded in Mannington, W. Va., wrecking six houses and badly scalding a son of James Dewer and a daughter of B. F. Cunningham.

(287.) — Charles Elliot, ——— Beavers, and Frank Spence, were killed on December 4th by a boiler explosion near Eastland, Texas.

(288.) — George Hammond and Joseph Showers were instantly killed, and Joseph Henderson was seriously injured, by the explosion of a boiler in Oxford, N. Y., on December 5th.

(289.) — By a boiler explosion at Oak Harbor, near Fremont, Ohio, on December 6th, W. Gordon, E. E. Monroe, and David Wright were badly scalded. Joseph Giester was also slightly injured. Giester was blown fully fifty feet.

(290.) — E. W. Otis and S. L. White were badly bruised and burned on December 7th, by the explosion of a boiler at Baldwinville, near North Adams, Mass. White is likely to die.

(291.) — A boiler exploded in Warsaw, Ill., on December 7th, fearfully scalding Mr. E. H. Porter, and breaking William A. Cochran's leg.

(292.) — A boiler explosion occurred, on December 8th, at W. E. Moore's saw-mill, near Lynchburg, Va. Fireman William Crews was instantly killed, and Samuel Davis was badly injured. Everything connected with the mill was completely wrecked.

(293.) — A slight boiler explosion occurred on December 9th in the township of What Cheer, Iowa. No person was hurt.

(294.) — By the explosion of a boiler in Brooklyn, N. Y., on December 9th, Alfred Orr and John Clark were badly bruised and scalded.

(295.) — A small boiler exploded on West Fifty-third street, New York, on December 11th. The damage was slight.

(296.) — Wilson Weathersbee was instantly killed on December 12th by the explosion of a boiler in Benton, Ill. Grant Whittington was standing near Weathersbee at the time, and although he was blown into a river, fifty feet away, he escaped serious injury.

(297.) — A boiler exploded on December 14th in Jacksonville, Pa., blowing the boiler-house to pieces, and injuring the engineer.

(298.)—A boiler at Newcastle, Pa., exploded on December 15th, fatally scalding Frederick Gettholtz, and seriously injuring Walker Gaston and Alexander Kerr.

(299.)—The Arcade building at Buffalo, N. Y., was destroyed by fire on December 15th. The fire was caused by an explosion of some kind in the boiler-room; and the loss amounted to over a million dollars.

(300.)—On December 16th a boiler belonging to J. J. Wright exploded in Thackerville, I. T. The boiler-house was demolished, and the machinery of the mill was ruined. Nobody was hurt.

(301.)—By the explosion of a boiler in Navy, W. Va., on December 18th, Allen Brown was killed, and Will Capley, Henry Capley, and Harvey Lewis were injured, the last two fatally so.

(302.)—Two boilers exploded at the Patterson colliery, Mt. Carmel, Pa., on December 18th. William Secano and Michael Hirsch were badly injured. Secano's injuries, in fact, are considered fatal.

(303.)—John W. Knipe and his son were killed, on December 19th, by the explosion of a boiler in Logan, Ohio.

(304.)—A boiler exploded at the Alexandria mills, across the river from Knoxville, Tenn., on December 22d. The plant was completely demolished. Harrison Caldwell, Sherrod Dupees, Louis Palmer, and James Whittle were killed; and Thomas Blair, Solomon Henry, Joseph Massey, James Miller, and James Reese were injured. Blair and Henry have only slight chances of recovering.

(305.)—A boiler exploded in Whitesburg, near Birmingham, Ala., on December 23d. Engineer Benjamin Thomas and Fireman Amos Banks were killed instantly, and three laborers received injuries from which they may die.

(306.)—A boiler exploded on December 28th in McDonald & Dice's mill, near Peru, Ind. George McDonald and his nephew, Richard McDonald, were instantly killed. Walter Dice, one of the owners of the mill, was injured by flying débris; and the mill itself was demolished.

(307.)—A boiler exploded at Point Breeze, near Philadelphia, Pa., on December 29th. The boiler-house was demolished and John Mannes was instantly killed. Robert Mealy was fearfully scalded, and his skull was fractured. It is believed that he cannot recover.

(308.)—On December —— a boiler exploded at St. Rose, St. James parish, La. One man was killed, and five others were frightfully scalded.

THE powers of certain miraculous curative places apparently do not extend to all diseases. W. R. Le Fanu, in his *Seventy Years of Irish Life*, gives the following testimony of an invalid, who had sought the benefits of the Knock Chapel: "Indeed, sir, I took all the rounds and said all the prayers, but it was of no use; not but what it's a grand place; it would astonish you to see all the sticks and crutches hanging up there, left behind by poor cripples who went home cured. It's my opinion, sir, that for rheumatism, and the like of that, it's a grand place entirely; but as for the liver, it's not worth a d—— n."—*Popular Science Monthly*.

Inspectors' Report.

NOVEMBER, 1893.

During this month our inspectors made 6,743 inspection trips, visited 14,706 boilers, inspected 5,241 both internally and externally, and subjected 537 to hydrostatic pressure. The whole number of defects reported reached 10,471, of which 1,058 were considered dangerous; 27 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	810	39
Cases of incrustation and scale,	1,591	65
Cases of internal grooving,	87	7
Cases of internal corrosion,	523	30
Cases of external corrosion,	654	44
Broken and loose braces and stays,	161	39
Settings defective,	229	25
Furnaces out of shape,	361	17
Fractured plates,	345	67
Burned plates,	227	26
Blistered plates,	276	12
Cases of defective riveting,	1,282	113
Defective heads,	93	20
Serious leakage around tube ends,	2,365	322
Serious leakage at seams,	359	29
Defective water-gauges,	331	80
Defective blow-offs,	115	42
Cases of deficiency of water,	11	6
Safety-valves overloaded,	52	11
Safety-valves defective in construction,	80	23
Pressure gauges defective,	471	38
Boilers without pressure gauges,	3	3
Unclassified defects,	45	0
Total,	10,471	1,058

DECEMBER, 1893.

During this month our inspectors made 7,642 inspection trips, visited 15,971 boilers, inspected 6,647 both internally and externally, and subjected 574 to hydrostatic pressure. The whole number of defects reported reached 12,335, of which 1,385 were considered dangerous; 83 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,127	71
Cases of incrustation and scale,	2,266	125
Cases of internal grooving,	179	18
Cases of internal corrosion,	776	40
Cases of external corrosion,	887	45
Broken and loose braces and stays,	276	89

Nature of Defects.	Whole Number.	Dangerous.
Settings defective,	291	46
Furnaces out of shape,	410	17
Fractured plates,	430	71
Burned plates,	320	33
Blistered plates,	338	25
Cases of defective riveting,	1,149	80
Defective heads,	165	53
Serious leakage around tube ends,	1,845	346
Serious leakage at seams,	550	62
Defective water gauges,	315	76
Defective blow-offs,	164	44
Cases of deficiency of water,	15	11
Safety-valves overloaded,	97	45
Safety-valves defective in construction,	96	26
Pressure-gauges defective,	601	57
Boilers without pressure-gauges,	3	3
Unclassified defects,	35	2
Total,	12,335	1,385

Summary of Inspectors' Reports for the Year 1893.

During the year 1893 our inspectors made 81,904 visits of inspection, examined 163,328 boilers, inspected 66,698 boilers both internally and externally, subjected 7,861 to hydrostatic pressure, and found 597 unsafe for further use. The whole number of defects reported was 122,893, of which 12,390 were considered dangerous. A summary of the work by months is given below, and the usual classification by defects is likewise given :

SUMMARY, BY DEFECTS, FOR THE YEAR 1893.

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	9,774	548
Cases of incrustation and scale,	18,369	865
Cases of internal grooving,	1,249	148
Cases of internal corrosion,	6,252	397
Cases of external corrosion,	8,600	536
Defective braces and stays,	1,966	485
Settings defective,	3,094	352
Furnaces out of shape,	4,575	254
Fractured plates,	3,532	640
Burned plates,	2,762	325
Blistered plates,	3,331	164
Defective rivets,	17,415	1,569
Defective heads,	1,357	350
Leakage around tubes,	21,211	2,909
Leakage at seams,	5,424	482
Water gauges defective,	3,670	660
Blow-outs defective,	1,620	425
Cases of deficiency of water,	204	107

Nature of Defects.	Whole Number.	Dangerous.
Safety-valves overloaded,	723	203
Safety-valves defective,	942	300
Pressure gauges defective,	5,953	552
Boilers without pressure gauges,	115	115
Unclassified defects,	755	4
Total,	122,893	12,390

Summary by Months.

Month.	Visits of inspection.	Number boilers examined.	No. inspected internally and externally.	No. tested hydrostatically.	No. condemned.	Number of defects found.	Number of dangerous defects found.
January,	6,853	14,226	4,702	568	71	10,322	1,040
February,	5,762	11,068	3,820	588	39	8,662	893
March,	7,071	13,943	4,955	787	52	10,454	1,561
April,	6,697	13,018	5,470	723	64	10,432	803
May,	7,300	14,160	6,082	722	52	10,834	919
June,	6,817	13,000	6,118	827	27	10,401	1,005
July,	6,413	10,557	7,711	671	58	11,138	1,039
August,	6,641	15,311	5,292	577	54	9,449	884
September,	6,693	12,835	5,405	647	26	8,881	734
October,	7,272	14,533	5,255	690	44	9,514	1,069
November,	6,743	14,706	5,241	537	27	10,471	1,058
December,	7,642	15,971	6,647	574	83	12,335	1,385
Totals,	81,904	163,328	66,698	7,861	597	122,893	12,390

The following short table shows the increase in the work of our inspectors during the past year :

Comparison of Inspectors' Work during the Years 1892 and 1893.

	1892.	1893.
Visits of inspection made,	74,830	81,904
Whole number of boilers inspected,	148,603	163,328
Complete internal inspections,	59,883	66,698
Boilers tested by hydrostatic pressure,	7,585	7,861
Total number of defects discovered,	120,659	122,893
" " of dangerous defects,	11,705	12,390
" " of boilers condemned,	681	597

The following table is also of interest. It shows that our inspectors have made over three-quarters of a million visits of inspection, and that they have made over a million and a half of inspections, six hundred thousand of which were complete internal inspections. Of defects, nearly a million and a quarter have been discovered and pointed out to the owners; and more than one hundred and fifty thousand of these were, in our opinion, dangerous :

GRAND TOTAL OF THE INSPECTORS' WORK SINCE THE COMPANY BEGAN BUSINESS, TO JANUARY 1, 1894.

Visits of inspection made,	796,725
Whole number of boilers inspected,	1,580,060
Complete internal inspections,	608,786
Boilers tested by hydrostatic pressure,	102,195
Total number of defects discovered,	1,206,309
" " of dangerous defects,	154,749
" " of boilers condemned,	8,406

We append, also, a summary of the work of the inspectors of this company from 1870 to 1893, inclusive. The years 1876 and 1878 are omitted, because the data that we have at hand for those years is not complete. The figures, so far as we have them, indicate that the work during those years was in good accordance with the regular progression observable in other years. Previous to 1875, it was the custom of the company to publish its reports on the first of September, but in this year the custom was changed and the summaries were made out up to January 1st, so as to agree with the calendar year. The figures given opposite 1875, therefore, are for sixteen months, beginning September 1, 1874, and ending December 31, 1875.

SUMMARY OF INSPECTORS' WORK SINCE 1870.

YEAR.	Visits of inspection made.	Whole number of boilers inspected.	Complete internal inspections.	Boilers tested by hydrostatic pressure.	Total number of defects discovered.	Total number of dangerous defects discovered.	Boilers condemned.
1870	5,439	10,569	2,585	882	4,686	485	45
1871	6,826	13,476	3,889	1,484	6,253	954	60
1872	10,447	21,066	6,533	2,102	11,176	2,260	155
1873	12,824	24,998	8,511	2,175	11,998	2,892	178
1874	14,368	29,200	9,451	2,078	14,256	3,486	163
1875	22,612	44,763	14,181	3,149	24,040	6,149	216
1877	......	32,975	11,629	2,367	15,964	3,690	133
1879	17,179	36,169	13,045	2,540	16,238	3,816	246
1880	20,939	41,166	16,010	3,490	21,033	5,444	377
1881	22,412	47,245	17,590	4,286	21,110	5,801	363
1882	25,742	55,679	21,428	4,564	33,690	6,867	478
1883	29,324	60,142	24,403	4,275	40,953	7,472	545
1884	34,048	66,695	24,855	4,180	44,900	7,449	493
1885	37,018	71,334	26,637	4,809	47,230	7,325	449
1886	39,777	77,275	30,868	5,252	71,983	9,960	509
1887	46,761	89,994	36,166	5,741	99,642	11,522	622
1888	51,483	102,314	40,240	6,536	91,567	8,967	426
1889	56,752	110,394	44,563	7,187	105,187	8,420	478
1890	61,750	118,098	49,983	7,207	115,821	9,387	402
1891	71,227	137,741	57,312	7,859	127,609	10,858	526
1892	74,830	148,603	59,883	7,585	120,659	11,705	681
1893	81,904	163,328	66,698	7,861	122,893	12,390	597

The Explosion on the "Brandenburg."

As we go to press, news is received of a terrible explosion which occurred at Kiel, on February 16th, on the German cruiser *Brandenburg*. The account says: "With the usual secrecy that pervades naval affairs, the officers of the ship refused to give any details regarding the accident, but it is known that many of the crew were killed, and that considerable damage was done to the vessel. The *Brandenburg* had had new boilers placed in her, and had been ordered to make a trial trip to test her. The vessel was on this trip when the explosion occurred. Forty men were instantly killed, and nine others were fatally wounded. Among the dead are three chief engineers who were on the vessel to report on the work of the boilers. Several other officers were also included. Most of the bodies were badly scalded, in some instances the faces being so swollen as to be unrecognizable. As soon as the effects of the explosion were known to the officer of the deck, he caused signals to be set showing that the vessel was helpless. Steamers went at once to the assistance of the disabled war-ship, and, getting lines to her, towed her back to Kiel. When she reached port, Prince Henry of Prussia, the Emperor's brother, immediately boarded her and found that the explosion had caused much damage. The steam tug *Pelican*, which was the nearest vessel, was the first to go to the *Brandenburg's* assistance; and she returned to the quay with thirty dead bodies. The news of the accident had spread through the city, and thousands had gathered at the landing place. Four other steam tugs brought the wounded ashore. Many of the crew were injured critically, and all the injured were taken to the Military Hospital for treatment. Six of these men died on the following morning, making the total number of deaths from the accident forty-six.

"The *Brandenburg* is a steel belted cruiser of 9,840 tons. Her dimensions are: Length, 354 feet 3 inches; beam, 64 feet. She draws 24 feet 7 inches of water. Her engines are of 9,500 indicated horse power, and she has a speed of sixteen knots an hour. She was built at Wilhelmshaven in 1891. From what could be learned from those who would talk of the accident at all, it appears that the main steam pipe of the starboard engine burst while the engines were developing only 7,300 horse power.

"Captain Bendemann of the *Brandenburg* received the following despatch from Emperor William: 'Accept my warmest sympathy and condolence for the loss of our heroes. We must keep a firm trust in God, and submit to the working of His inscrutable will. Then we may find consolation and confidence. I shall cause a tablet commemorating the dead to be placed in the garrison church at Kiel. For those that are left, full steam ahead.'"

So much has been written and said on the cancellation of orders and the return of goods once purchased, that the rights of both seller and buyer are becoming more clearly defined under the law. Both parties have certain rights, and the suits that are occasionally growing out of the infringement of these rights are having a good effect, at least in the way of defining precisely what one can or cannot do under the law. Many retail merchants have an idea that they can refuse to accept goods at any time after ordering. Such would not seem to bet he case under the decision of the Supreme Court of Georgia, in the case of McCord *vs.* Laidley, wherein a firm bought a carload of goods to be shipped and paid for on delivery. The seller shipped the car and forwarded a draft. The draft was presented before the car arrived and payment refused, and the buying firm notified the seller that he had violated the contract by demanding payment before the delivery of the goods, and that they would not accept the goods when they arrived. When the car arrived it was tendered to the buyers and they refused it. It was then sold for what it would bring, which was much less than the contract price. The buyers were held by the court to be liable for the deficit. The decision is not only good law, but sound common sense, and would undoubtedly be cited as a precedent in all similar cases.— *Wade's Fibre and Fabric.*

The Locomotive.

HARTFORD, FEBRUARY 15, 1894.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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Mr. William Gaston.

It becomes our sorrowful duty to announce the death of ex-Governor William Gaston of Massachusetts, who passed away on January 19th, in the 74th year of his age. Mr. Gaston was an honored and distinguished citizen, and for years had been the State attorney for the Hartford Steam Boiler Inspection and Insurance Company. He was widely known in public life, and was respected by his political opponents as well as by his friends. He was a man of the strictest integrity, and was thoroughly conscientious in all his relations. He was born in Killingly, Conn., on October 3, 1820. He was graduated at Brown University in 1840, and immediately afterwards he began the study of law, being admitted to the bar in 1844. He opened his first law office in Roxbury, Mass., in 1846, and continued his practice there until 1865, when he formed a partnership with Hon. Harvey Jewell and Hon. W. A. Field, and removed to Boston. In 1853 and 1854 Mr. Gaston was elected to the legislature as a Whig, and in 1856 he was re-elected by a fusion of the Whigs and Democrats. In 1861 and 1862 he was mayor of Roxbury, and during that period he was very active in raising troops for the Union cause. In 1868 he was elected to the State senate. In 1871 and 1872 (after the annexation of Roxbury) he was mayor of Boston. It was during his second term as mayor that the great Boston fire occurred; and in the trying times that ensued Mr. Gaston proved the sterling qualities of his character, and amply justified the confidence his friends had reposed in him. In 1874 he was elected governor of Massachusetts. In a notice of his death, the *Boston Herald* justly calls him "an able advocate, an eloquent, forcible speaker, and a thoroughly conscientious man," and adds that "every position to which he was called he successfully filled, and during his long career, occupying many positions of trust, both public and private, the breath of suspicion was never wafted toward him. Men might differ with him politically, but of his thorough honesty and sterling integrity there was but one opinion; and, as was said of him long ago, he was a man pre-eminently qualified for duties requiring 'wisdom, discretion, firmness, and courage when needed, combined with the most exalted integrity and unselfish devotion to the honor, welfare, and prosperity of the city.'"

MR. Edward P. Thompson, whose book ("*How to Make Inventions*") we commented upon a short time ago, writes as follows concerning our criticisms in the December issue: "You remark, 'On page 36 he states that sound moves faster and faster from its source until a certain maximum is obtained. We should like to be referred to the experiments or equations on which this statement is based.' I refer you, therefore, to Jacques's experiments found described in any standard work on physics. See, for example, Ganot, section 230, as follows: 'He (Jacques) thus found that nearest the gun the velocity (of sound) is least, increasing to a certain maximum which is considerably greater than the average velocity.' You also state, 'On page 44 we read that "water boils in glass vessels at 106° C., and in metal vessels at 100° C. A piece of metal placed in the glass vessel makes the water boil at 100° C." This would be an extraordinary fact, if it were a fact, which unfortunately it is not.' I refer you therefore to any account of Gay-Lussac's experiments; for example in Ganot, section 366, which gives the same figures, merely adding that the vessels must be chemically clean.

"I can change but cannot improve the wording of a clause you quote from page 33: 'Water vapor in contact with red-hot material is decomposed into hydrogen and oxygen, which are combustible, relatively.' You allege obscurity, especially as to the latter part. The word 'relatively' is necessary to show that hydrogen will burn in oxygen, or oxygen in hydrogen. If 'relatively' were omitted, the inventor might infer that oxygen is combustible in air."

There is a fine irony in referring us to "any standard work on physics" for support of the indefensible proposition about the speed of sound, quoted above. Mr. Thompson's statement was sweepingly made, about sounds in general. He said nothing to his readers about cannon, and so far as any one could judge, he intended the statement to apply to sounds of all kinds. In fact, whenever an unqualified statement about any kind of a wave-motion is made, physicists always understand that the amplitude of the waves is *small;* which was not the case in Jacques's experiments. Moreover, the air in the vicinity of a cannon is thrown into such a violent commotion by the discharge of the cannon, that it would be manifestly unfair to draw conclusions about sound from such experiments, with the expectation that they will be true of sounds *in general.* It is known, for example, that the sound of a cannon-discharge is not propagated with the same speed in all *directions*; yet we imagine that Mr. Thompson would hardly feel justified in modifying this statement so as to make it read "Sound travels with different speeds in different directions."

We even venture the suggestion that Jacques's experiments may not be above reasonable suspicion; though this makes no difference whatever, so far as the foregoing discussion is concerned. Thus he found that with half-pound charges of powder the velocity was 1,032 feet per second at a distance of 40 feet or so from the cannon, and 1,120 feet per second at a distance of about 75 feet. If we make the reasonable assumption that the speed was determined in each case by observing the time required for the sound to travel 40 feet — this is probably the *greatest* distance that would be admissible — we find that the observed time of transmission for velocities of 1,032 feet and 1,120 feet, would be .0388 of a second and .0357 of a second, respectively. The difference between these intervals is .0388 − .0357 = .0031 of a second; hence to *prove* the lesser velocity near the cannon, M. Jacques would have to determine, with precision, an interval of time less than the three-hundredth part of a second. Taking the nature of the experiment into consideration, we should say that this would be practically impossible, even if there were not a cannon banging away all the time at one's elbow.

So far as the boiling-point of water is concerned, let us say that the circumstance (which Mr. Thompson now mentions for the first time) that the experiment will not succeed unless the vessel is "chemically clean," is of the most extreme importance; and a statement in which this condition is omitted is certainly not true. Of course it is well known that water "bumps" when it is boiled in smooth, clean glass vessels; it is also known that water may be heated much *more* than 6° above the boiling point, if proper precautions are taken. But since it is these very precautions that make the experiments *possible*, statements that do not even remotely suggest that there are any such conditions of success, can only be characterized as misleading and untrue.

Now about the oxygen and hydrogen. If Mr. Thompson had only put *in his book* the explanation he now offers, all would have been clear as day. But the lucid explanation that he now gives does not alter the fact that the original passage was obscure.

Reminiscences of the Fair.

Of the millions of persons who attended the Columbian Exposition, surely there was not one who was not filled with consternation when word came that the Manufactures building was ablaze. On every side there were expressions of sorrow and sympathy for the exhibitors who had not yet removed their goods when the flames burst forth. It is hard to believe that the beautiful peristyle is gone — that in a few short moments it was resolved into its elements and whirled high into the heavens, to exist no more. Visitors who stand where we stood only a little while ago, no longer gaze on those graceful columns and beautiful statues. Nothing is there, now, but desolation.

There may have been men in the beginning who doubted the ability of Chicago to produce an exposition that should excel the Centennial Exposition, and compare favorably with the one so recently held in Paris; but those once dubious must surely now admit their mistake, and acknowledge that Chicago has accomplished all she undertook to accomplish, and that she has given us an Exposition greater and better than any nation has yet produced in the history of the world. Her proud motto, "*I will*," might properly be exchanged for the prouder one, "*I did*."

It was well worth a trip across an ocean and half a continent, to see the buildings and grounds of the White City; and the American people would have been proud to acknowledge the Fair as their own, had there been nothing else on exhibition there. Surely, there is no man who is not thrilled when he looks back at that grand Court of Honor, with its magnificent architectural effects, and beholds, in imagination, the placid waters of the lagoon with the picturesque gondolas and gaily-dressed gondoliers,— the noiseless electric launches flitting about, impelled by some unseen force, — the long lines of electric lamps, threading their way over the great buildings, and sparkling on the ripples of the lagoon, as some saucy, puffing steamboat passed by,— the powerful search-lights wandering about, bringing one object after another into brilliant relief,— and the glories of the luminous fountains, spouting crimson, purple, and golden fire. Such a fairy-like vision was never beheld before, nor ever conceived, save in the imaginative minds of poets.

If one were asked what country made the grandest exhibit there, would he say Italy? or Germany? or Japan? There was a country that made a small exhibit in the Agricultural building. It was a little villa surmounted by a dome, and in it there were olives and pickles. That country was Greece; and when his eye fell upon this exhibit, the visitor, with no thought of disparaging the olives and the pickles, could scarcely refrain from a start of surprise. He asked himself, unconsciously — Can *this* be the exhibit of Greece, the garden of the world, and the home of all that is great and beautiful in art? And when, in contemplative mood, he left the Agricultural building and came out once more into the Court of Honor, and raised his eyes again to the grandeur of the buildings about him, he exclaimed, "*This* is the exhibit of Greece! She made it possible to design these magnificent structures; and the architectural glories of the Exposition are hers as well as ours."

Without doubt the most impressive exhibit at the fair, aside from the buildings and grounds, was in the electrical department. The advance in this line of investigation could not fail to impress profoundly anyone who had previously seen the Centennial Exposition. A great deal has been written on this subject, during the Exposition and since its close, but we have seen nothing that expresses the facts of the case better or simpler than these words of Prof. Dolbear, in a recent issue of *The Cosmopolitan.* "Then [*i. e.*, in 1876]," he says, "electrical apparatus consisted mostly of telegraphic devices, galvanic batteries, static machines, leyden jars, and measuring instruments such as galvanometers and resistance coils. There were a few crude dynamos and one small imported Gramme machine, none of them intended to maintain more than one arc light. Now there is rivalry for space in which to exhibit dynamos capable of lighting 50 or more in one circuit. Then, there was not a single incandescent lamp in the world. Now, they are to be seen by the tens of thousands, and with all degrees of brightness, from that of a tallow dip to those but little inferior to the arc itself; and every exhibit is thus lighted. Then, there was not a single electrical motor that was more than a toy to be run by a galvanic cell. Now, there are motors for all kinds of service, from driving a fan to those running printing-presses, looms, and machine shops, and threatening the existence of the locomotive itself. Then, all welding was done by hammering at the forge. Now, electricity heats the ends to be joined, and, in less time than it takes to describe the process, heavy shafts and rails may be welded even better than was possible before. Then, it was not possible to weld steel, or other metals than iron. Now, almost any metal may be electrically welded to another, as easily as iron to iron. Then, there were induction coils for producing sparks a few inches long. Now, such sparks have been made five feet long, and it is believed they could be made fifty feet long if it were worth the while. Then, induction coils were employed only for changing low potentials to higher. Now, the transformer reverses the process and makes electric lighting feasible miles away from the dynamo. Then, it was possible to send but two telegraphic messages in opposite directions over the same wire, at the same time. Now, 72 messages can be sent simultaneously over one wire, 36 in each direction, and without the least interference or confusion. Then, the telephone was first exhibited on a line the length of the building. Now, one can talk with another a thousand miles away. Then, it was believed that a continuous conductor was essential for doing any kind of electrical work. Now, it is shown that all kinds of such work may be done without material connections. Then, it was thought that light was one of the physical forces. Now, it is believed that light is an electro-magnetic wave. Then, it was believed and taught that electricity could never be economically employed for driving machinery, and that its light could not be subdivided. Now, it is believed that electricity is in its infancy. Then, all the electrical exhibit could be put in a space 50 feet square. Now, a huge building, covering acres, is found insufficient for the needs of exhibitors. All this since 1876."

There was still another exhibit that attracted the notice of thoughtful visitors, though it was not down on the program. We refer to the deportment of the crowds. It was really inspiring to see a great crowd of American citizens moving about in an orderly manner, and thoroughly on what is sometimes called "their good behavior." Let no cynical reader imagine that we mean to intimate that such a sight is in any way uncommon in smaller assemblies, nor that it is not to be expected in larger ones. We mean simply that it is not often that we have the opportunity of observing such multitudes of people gathered into one place; and that whenever we *do* have such an opportunity, we find that they behave precisely as we should hope and expect they would. Nevertheless, it makes us proud of them when we behold the fulfilment of our expectations. Even on Chicago Day, when the grounds were thronged almost to their full capacity with tired men and women, if a man inadvertently jostled against you, he begged your pardon and possibly went so far as to raise his hat; and a similar spirit of good nature was everywhere visible.

It was a great Fair.

Canal Works in 1893.

The year 1893 witnessed the completion of the Corinth Canal, a work which may be said to have been in contemplation for the last 2,400 years. The *Engineer*, London, says surveys and borings were actually made, and the work partially commenced, in the reign of the Emperor Nero. The work remained in abeyance till the success of the Suez Canal led to the scheme assuming a practical shape in 1881; and, after overcoming several financial difficulties, the canal was opened for traffic in August last. The length of this canal is only four miles; but the undertaking has been costly, the cutting being principally through rock.

The Manchester Ship Canal was completed during the year, and its opening for traffic was a most notable event. The weather during the year was very favorable to the progress of the works, which were hindered, in previous years, by interruptions caused by floods and tempests. The principal works completed during the year were those for the deviation of the London and Northwestern and Great Western Railways, and the opening of these deviations first for goods traffic and later on for passengers. When this was accomplished there remained the cutting through the site of the old lines. The final completion of this part of the work was considerably delayed by the settlement of the claims of the companies for compensation, which, however, in the end resulted in a favorable award to the canal company, the amount they had to pay being only about one-fourth of that claimed. Several large, swing bridges and the swinging aqueduct at Barton were also completed during the year. The other principal works which have been brought to a successful termination are the embankment of the Mersey, near Runcorn, and the underpinning of Runcorn Bridge. At the end of November the water was let into the last section of the canal, and on December 7th the first steamboat passed from the Mersey, at Eastham, to Manchester. The canal was traversed in 6¼ hours, although there were delays, owing to several of the bridges and the Barton Aqueduct being swung by hydraulic power for the first time. The works were commenced on November 11, 1887, and thus this great undertaking has been completed in the short space of seven years. Meantime, on the lower reach of the canal, business has been rapidly growing, and Saltport, which a year ago hardly had an existence, is now a busy port. From the commencement of 1894, steamers from America will proceed direct to Manchester, and arrangements have been made by different companies for regular traders to Amsterdam, Rotterdam, Antwerp, Dunkirk, Terneuzen, Hamburg, London, Belfast, and other ports.

No further progress appears to have been made for carrying out the Sheffield and South Yorkshire Navigation scheme, and the junction of this system of canals with the Aire and Calder. The scheme, however, is not dead, as a notice has been given by the company of their intention to apply to Parliament for powers to obtain land beyond that which is to be given over by the railway company. The amount to be paid for the existing canals, which is to be determined by the railway commissioners, has not been settled.

The Panama Canal still remains in a state of ruin. An extension of the concession has been obtained from the Colombian government up to October, 1894, and attempts have been made to form a new company to go on with the work, but, so far, without success. The Nicaragua Canal is also in difficulties. Owing to the state of financial matters in America, it was found impossible to raise money to go on with the work, and in order to protect the works and plant, the Nicaragua Canal Construction Company was placed in charge of a receiver. The company has expended about £800,000 for property, work, labor, and materials, and has, as elsewhere mentioned, recently been reconstructed. The works of the Chignecto Ship Railway Company have been also at a standstill for more than a year, and are going to ruin for want of funds. Over a million of money has been spent, and it is estimated that it will require another half-million to complete the railway.

The North Sea Baltic Canal has been making considerable progress, about 5,000 men being employed, one-half of whom are housed in barracks erected by the canal authorities. A large number of the men are Swiss and Italians, these men being preferred on account of their sober habits. Up to the present time about 100 million cubic yards of earth have been moved. At Holtenau the locks are in working order, and some of the large bridges for carrying the roads and railways over the canal are completed. The estimated cost of this canal is £7,800,000, and it is expected it will be completed in 1894 — seven years after its commencement.

Abroad several important works for improving ports and harbors have been completed during the year. At Tunis a new channel has been opened, from the gulf to the town. At Alexandria a new straight and deep channel has been made to the port. Several important works for the improvement of the harbor of Bilbao have also been completed ; and also at the port of Lido, for improving the navigation to Venice.

In America, the works for connecting Chicago with the Mississippi by means of a canal joining Lake Michigan with the Illinois River are progressing. It is considered that this canal will, for all practical purposes, place the Mississippi cities a thousand miles nearer the Atlantic seaboard, and double the value of the Western lands. The canal on the Canadian side of St. Mary's River, for giving communication between Lakes Huron and Superior, and allowing vessels bound for the St. Lawrence to pass this way instead of through the Sault Ste. Marie Canal, is expected to be completed in July, 1894. This canal is 3,500 ft. long, and will have a lock 900 ft. long, 60 ft. wide, with 19 ft. of water on the sill. The United States at present charges 20 cents per ton on all freight passing through the Sault Ste. Marie Canal and going to any port in the Dominion of Canada, vessels going to the States passing through free. The importance of completing the works, so as to give Canada the control of the great waterway from Lake Superior to the St. Lawrence, is obvious.

At Montreal the works for the improvement of the harbor and the shipping accommodation have made good progress. These consist of a guard pier 1¼ miles long, 45 ft. wide at top, and 20 ft. above low water, extending from the abutment of the Victoria Bridge down stream, for the purpose of protecting the harbor from the floods and the ice. This pier will inclose a basin of 250 acres. The material dredged and excavated from the basin is used for the construction of the pier. Inside this harbor extensive wharves are to be erected. The pier will require about a million cubic yards of materials, of which about one-third is already in place. The estimated cost of this work is £624,000, and it is expected that it will take three years to complete. — *Scientific American.*

The Locomotive.

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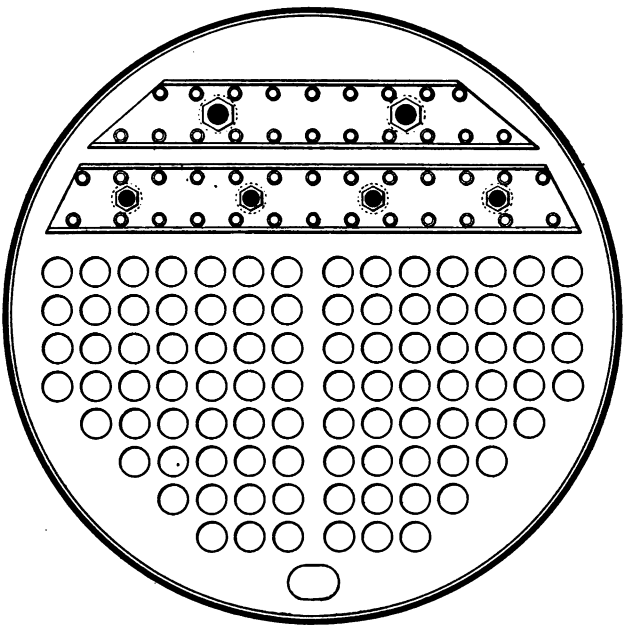
Through Bracing.

In the February issue of The Locomotive we illustrated a method of through bracing, in which the braces were provided with upset ends, and the heads were stiffened by channel bars. The present illustration shows the same general form of bracing as applied to a 72-inch boiler, except that the steel channel bars in the present instance are heavier, and have a width of eight inches; the increased width allowing the rivets to be



Arrangement of Through Braces and Channel Bars.

spaced in such a way as to provide a more uniform support to the head. The arrangement of the channel bars and the distribution of the rivets must, of course, be governed by the size of the boiler and the amount of steam pressure to be carried. When the pressures are high, a diagonal brace, running to the shell in the usual manner, may be placed between the longitudinal braces on the upper channel bar.

The braces used should be of the best quality of iron, and they will vary in diameter according to the pressure that the boiler is designed to carry. They will also vary, of course, with the diameter of the boiler, as the area to be braced will be greater in larger boilers than in smaller ones. The arrangement of braces shown in the illustration is designed for a boiler of 72 inches diameter, as we have already said; and in such boilers the diameter of the four lower braces will vary from 1½ inches to 1⅞ inches, and the diameter of the two upper ones from 1⅞ inches to 2¼ inches. These measurements, of course, are for the straight section, or main body of the brace-rods; the upset ends being always in proper proportion to the size of the body of the brace.

To facilitate the selection of proper sizes of through braces, we append the following table, in which the column headed "Strength of the brace," gives the allowable load in pounds, for round braces, based on a tensile strain of 7,500 pounds per square inch of sectional area. The rest of the table will explain itself.

DIMENSIONS AND STRENGTH OF UPSET BRACES.

Diameter of Brace in inches.	Area of cross-section in square inches.	Strength of Brace, in pounds.	Standard diameter for the upset ends.
¾	0.442	3,310	1
⅞	0.601	4,510	1⅛
1	0.785	5,890	1⅜
1⅛	0.994	7,450	1½
1¼	1.227	9,200	1⅝
1⅜	1.484	11,130	1¾
1½	1.767	13,250	1⅞
1⅝	2.073	15,550	2
1¾	2.405	18,040	2⅛
1⅞	2.761	20,710	2¼
2	3.141	23,560	2⅜
2⅛	3.546	26,590	2½
2¼	3.976	29,820	2⅝
2⅜	4.430	33,220	2⅞
2½	4.908	36,810	3

Inspectors' Report..

JANUARY, 1894.

During this month our inspectors made 9,334 inspection trips, visited 17,973 boilers, inspected 6,430 both internally and externally, and subjected 525 to hydrostatic pressure. The whole number of defects reported reached 10,615, of which 1,110 were considered dangerous; 79 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	897	90
Cases of incrustation and scale,	1,749	79
Cases of internal grooving,	92	10
Cases of internal corrosion,	545	33
Cases of external corrosion,	787	60
Broken and loose braces and stays,	170	64
Settings defective,	287	24

Nature of Defects.	Whole Number.	Dangerous.
Furnaces out of shape,	366	18
Fractured plates,	383	67
Burned plates,	315	30
Blistered plates,	232	13
Cases of defective riveting,	1,177	46
Defective heads,	101	23
Serious leakage around tube ends,	1,638	283
Serious leakage at seams,	612	43
Defective water gauges,	368	44
Defective blow-offs,	145	45
Cases of deficiency of water,	24	18
Safety-valves overloaded,	52	15
Safety-valves defective in construction,	83	45
Pressure gauges defective,	519	34
Boilers without pressure gauges,	26	26
Unclassified defects,	47	0
Total,	10,615	1,110

Boiler Explosions.

JANUARY, 1894.

(1.) — A boiler explosion occurred at the Seafield Foundry, Buckie, Ill., on December 19th. Mr. William Adam, the senior proprietor, was killed. [Received too late for insertion in the December list. — ED.]

(2.) — Charles Beckert and Jesse Lang were killed on January 1st, by the blowing out of a screw plug in a boiler in Chattanooga, Tenn. The men were scalded to death.

(3.) — On January 1st, while the big tow-boat *Beaver*, which had come down from Pittsburgh with a tow of coal barges, was at Nine Mile Point, just above New Orleans, La., her auxiliary boiler exploded. Several men were engaged in cleaning out the main boiler at the time. Daniel Gough, the fireman, was fatally scalded, and F. R. Sauverain was slightly injured by the force of the concussion. The property loss was about $1,500.

(4.) — On January 1st, the boiler of engine No. 618, drawing freight train No. 12, bound for St. Louis, exploded at Higgmonson station, forty-five miles north of Little Rock, Ark., on the St. Louis, Iron Mountain & Southern Railway. Head brakeman David Ross was killed instantly, and fireman A. Doolen was badly scalded, and will probably die. The train was made up of thirty-five cars, fourteen of which were loaded with cattle, immediately behind the engine. Four of these cars jumped the track, and nearly all the cattle were killed. Nine cars, in all, were demolished. W. J. Mathews, the engineer, escaped uninjured, although he was blown 100 feet from the engine. Pieces of the engine were found 150 yards from the scene of the explosion.

(5.) — The steamer *Nisbet*, of the Evansville, Paducah & Tennessee River Packet Company, exploded her donkey boiler on January 2d, at Panther Creek, Tenn., sixty-five miles above Paducah, Ky. The front cabin was wrecked, and James C. Mitchell was killed. A number of the passengers and crew were also injured.

(6.)—On January 2d, a small heating boiler exploded in Minneapolis, Minn., doing some damage, but fortunately injuring nobody.

(7.)—A boiler exploded in Beaver Falls, Pa., on January 4th, totally wrecking the building in which it stood. The boiler passed diagonally over two squares, and landed several hundred yards away. The smoke-stack was blown a quarter of a mile through the air. Fortunately nobody was injured. The boiler was a small upright, with a single flue. It was six feet high and 36 inches in diameter, and the plates were of quarter-inch steel.

(8.)—A boiler exploded at St. Charles, Sumter Co., S. C., on January 6th. Mr. John E. Law was blown through the roof of a shed and instantly killed. His body was fearfully mangled. J. J. Luckey, Henry Monaghan, Cantey Bullock, Samuel Solomon, and Moses Perry were badly bruised and scalded.

(9.)—A boiler in Wilson Bros.' mill, in Adelphi, Ohio, exploded on January 11th, blowing the mill to atoms, and instantly killing Noah Hoffman, Silas Wilson, and Amos Stephens. The bodies of Stephens and Wilson were found a mile away. John Wilson was also injured, and it is believed that he cannot recover.

(10.)—The locomotive *Starr King* was blown to pieces at Belmont, N. H., on the Belmont branch of the Concord & Montreal railroad, on January 11th, just as it was leaving the station with a train. Engineer Edward Bowler had his jaw broken and his head crushed, and was dangerously injured in other ways also. Fireman John Ballantyne was horribly scalded about the body and legs.

(11.)—One of the boilers in the City Hall at Philadelphia, Pa., exploded on January 11th, but fortunately nobody was injured, and the building was not materially damaged. The water is said to have been low, so that the fire-sheet became overheated, and blew down.

(12.)—A slight explosion occurred at Tacoma, Wash., on January 13th, at the Crescent Creamery company's building on the ocean dock. Nobody was seriously injured, though Chief Engineer Follette was blown through a door.

(13.)—A boiler exploded on January 13th, in Willy & Co.'s flour mill, at Appleton, Wis. The boiler-house was totally destroyed, and Joseph Barta, the night engineer, was killed. Half of the boiler was blown 500 feet away. The property loss was about $5,000.

(14.)—The boiler of locomotive No. 383, of the "Big Four" railroad, exploded on January 14th, at Winchester, Ind. Albert Rankin, the fireman, was frightfully scalded and bruised, and died in about half an hour. Lafayette Mullin, the engineer, and Edward Dotey, head brakeman, were somewhat injured. An unknown young man, who had just boarded the engine, was also bruised to some extent. The locomotive was totally wrecked.

(15.)—On January 15th the boiler on the ferry-boat *Acorn* exploded at Middleport, near Gallipolis, Ohio. Engineer Joseph Petit was scalded to death, and the boat was badly damaged.

(16.)—One of the boilers in Lukens & Reifsnyder's mill, in Sumter, S. C., exploded on January 15th. John Kennedy was severely injured, but probably not fatally so. Thomas Smith, Ransom Pea, Hampton Carr, Steven Mack, and Simon Witherspoon were also injured. The boiler-house and another adjoining building were demolished.

The whistle belonging to the mill was found about five hundred yards away. The explosion was caused by internal corrosion, which affected only one plate, the others being still sound and good, while the defective one was only a sixteenth of an inch thick in some places. When the explosion occurred the steam gauge indicated only 65 pounds. The property loss was variously estimated at from $7,000 to $10,000.

(17.) — On January 16th a boiler at the breaker of the Reading Company's Indian Ridge colliery at Shenandoah, Pa., exploded and badly damaged the breaker and other buildings. The colliery was necessarily idle for a considerable time, and 780 persons were thrown out of employment.

(18.) — A boiler exploded in Roder's mill, near Sumner, Ill., on January 17th, and Engineer Wilbur E. Smith was killed. Smith was firing up for the day's work. The pipe leading from the boiler to the steam gauge had become clogged, and the gauge registered only 20 pounds. Smith was blown 175 feet, and death was instantaneous.

(19.) — The boiler of a steam tug exploded in Wallabout basin, near New York, on January 17th, and the rear end of the boat was blown away. The tug had been tied up for the night, and there was nobody aboard. The loss was estimated at $3,000.

(20.) — On January 17th, a boiler exploded in J. J. Elliott's mill, near Portsmouth, Ohio. The entire mill was demolished, and Engineer John Stout was fatally scalded. Mr. Elliott was also seriously and perhaps fatally injured. Both of his legs were broken, and it is likely that he received internal injuries in addition.

(21.) — One of the boilers in the Summit mill, at Philmont, N. Y., exploded on January 18th. Virgil Palen was badly cut and bruised, and three others received lesser injuries. The boiler was a new one, and it is said that at the time of the explosion it was carrying only about 35 pounds of steam. Part of the east wall of the building was blown out, and the machinery in the carding room was seriously damaged.

(22.) — On January 18th a boiler exploded at the Cumberland Coal company's mines, near Sturgis, Ky. Engineer George Monroe was killed, his body being frightfully mangled.

(23.) — A boiler exploded on January 22d at Kidd & Shackelford's mill, near Newnan, Ga. William Kidd and Oscar Herring were instantly killed.

(24.) — A slight boiler explosion occurred, on January 23d, in Colorado Springs, Col. The damage was not great.

(25.) — By the explosion of a heating boiler near San Maros, Tex., Herman Heidenheimer and E. Vining were killed, and Roland Simmonds, George Huff, and James Storrs were badly injured.

(26.) — On January 27th, locomotive No. 641, a big eighty-ton engine of the Iron Mountain Company, while standing in the yard at Poplar Bluff, Mo., ready to go out on a trip, exploded her boiler, shaking the earth for two miles. Conductor Chappell was slightly injured.

(27.) — A boiler exploded at the Loomis coal bank, near Wadsworth, Ohio, on January 28th. No one was injured. The damage is not stated.

(28.) — On January 29th, a boiler over a puddling furnace exploded in the Duncannon Iron Company's works, at Duncannon, Pa. One end of the mill and part of the roof were demolished, and J. L. Sommer, Harry Sommer, and Amos High were seriously bruised and scalded.

(29.) — The boiler of a mine locomotive exploded on January 29th at the Cranberry colliery, near Hazleton, Pa. Engineer Adam Greley and Fireman Michael Connell were seriously and perhaps fatally scalded and bruised.

(30.) — A boiler exploded on January 30th at Crow Hickman, a station on the Owensboro & Nashville Railroad, nine miles south of Owensboro, Ky. Taylor Parrish, John Mercer, Robert Slade, Edward Holder, and William Varbele were killed, and James Mercer was fatally injured, and one other man was injured in a lesser degree.

(31.) — A slight boiler explosion occurred in Brooklyn, L. I., on December 9, in the basement of an apartment house in Garfield Place. Alfred Orr was badly bruised and scalded, and John Clark and Harry Grant received lesser injuries. The newspaper account says that "Orr, who had charge of the heating apparatus, had just turned off the safety-valve, as he noticed that the boiler was making too much steam, when the cylinder-head of the boiler blew out" (!)

Explosions of Kitchen Boilers and Heaters.

It is commonly imagined, by those whose attention has not been called to the actual facts, that kitchen boilers and low-pressure heaters do not often explode. It is exceedingly difficult to collect statistics of these accidents in this country, because such boilers are exempt from inspection by the State, and are too frequently not placed under the care of any boiler insurance company; yet we believe that if complete statistics of such explosions *could* be compiled, they would make a most amazing showing. The cause of accidents of this kind has recently been under discussion in the columns of our esteemed English contemporary, *Engineering*, and Mr. Lavington E. Fletcher, Chief Engineer of the Manchester Steam Users' Association, has contributed to it a list of the explosions of this kind that occurred in England and Scotland during a recent "cold snap" that lasted five days. Judging from the difficulty of collecting these statistics, we think it is safe to say that Mr. Fletcher's list contains only a fraction of the total number of explosions that occurred during that period. It is, however, sufficiently imposing as it stands; and it can hardly fail to impress every one who reads it. We give it below:

No. 1. Friday, Jan. 5th, 1894. — London, Battersea. Explosion in a dwelling-house, wrecking the kitchen and injuring one man.

No. 2. Friday, January 5th. — London, Upper Norwood. Explosion in a dwelling-house, wrecking the kitchen and killing the maid-servant. Verdict of the coroner's jury, "Accidental death."

No. 3. Friday, January 5th. — London, Central Hill, Norwood. Explosion in a dwelling-house. Side of the house blown completely out.

No. 4. Friday, January 5th. — London, 22 Grafton street, Piccadilly. Explosion in the residence of Lady Mary Scott. A child killed instantly and two women injured.

No. 5. Friday, January 5th. — Lewisham. Explosion in the rooms of the St. James Young Women's Christian Association, wrecking the kitchen and injuring two women.

No. 6. Friday, January 5th. — Brighton. Explosion in a residence, completely wrecking the kitchen.

No. 7. Friday, January 5th. — Birmingham, Edgbaston. Explosion in a dwelling-house, blowing out the kitchen windows.

No. 8. Friday, January 5th. — Worcester. Explosion at Lloyd's bank ; kitchen wrecked completely.

No. 9. Friday, January 5th. — Bognor. Explosion in a dwelling-house, completely wrecking the kitchen, and inflicting terrible injuries on a maid-servant, from the effects of which she died next day. Verdict of the coroner's jury, "Accidental death." An engineer who had been working about the house recommended that the fire should be drawn. The jury thought he ought to have seen that his recommendation was acted upon.

No. 10. Friday, January 5th.—Macclesfield. Explosion at Langley Board School. The boiler of the heating apparatus burst, slightly damaging the premises.

No. 11. Friday, January 5th. — Kidderminster. Explosion at the School of Science. The boiler of the heating apparatus burst, blowing down the brickwork and severely injuring the man in charge.

No. 12. Saturday, January 6th.— London, East Finchley. Explosion in a dwelling-house, wrecking the kitchen and killing the cook and housemaid, the one having her arms and neck broken, and the other a portion of her head cut off. A plumber or boiler fitter had been consulted just prior to the explosion, and he had sanctioned the lighting of the fire. The owner's son was a hydraulic engineer. Verdict of the coroner's jury, "Accidental death."

No. 13. Saturday, January 6th.— Preston. Explosion at Daisy Bank, Ashton-on-Ribble. The kitchen boiler burst while the family were at dinner, wrecking the kitchen and blowing a large hole through the wall of the adjoining house, the fireplace of which was also blown out. A girl nine years old was killed, and three other persons were injured. Verdict of the coroner's jury, "Accidental death." The jury also recommended "that the corporation of Preston be requested to require the owners of all houses to fix safety-valves to all hot-water supply arrangements."

No. 14. Saturday, January 6th.—Liverpool, Lesseps-road. Explosion in a dwelling-house, wrecking the kitchen, blowing the oven through the ceiling, and severely injuring the maid-servant.

No. 15. Saturday, January 6th.— Liverpool, Jermyn street. Explosion in a dwelling-house, demolishing the kitchen and severely injuring the maid-servant.

No. 16. Saturday, January 6th. — Liverpool, Vandyke street. Explosion in a dwelling-house, wrecking the kitchen, and injuring three children who were sitting before the fire.

No. 17. Saturday, January 6th. — Manchester, Knoll street, Higher Broughton. Explosion in a dwelling-house, severely injuring four women.

No. 18. Saturday, January 6th.— Heywood. Explosion in a draper's cellar, setting the shop afire, and doing damage to the amount of $7,500.

No. 19. Saturday, January 6th. — Blackpool, South Shore. Explosion in a dwelling-house, blowing the grate to atoms and injuring two women.

No. 20. Saturday, January 6th.— Leeds. Explosion at the Adel Reformatory. The boiler of the apparatus used for heating the chapel burst, killing two lads who were in charge of it. Verdict of the coroner's jury, "Accidental death."

No. 21. Saturday, January 6th.—Oldham. At the Waterloo street Free Church the boiler of the heating apparatus burst, wrecking the heating chamber and vestry.

No. 22. Saturday, January 6th.— Selkirk. At the Parish church the boiler of the heating apparatus burst, blowing out the doors of the building.

No. 23. Saturday, January 6th.— Glossop. At the Tabernacle Sunday-school the boiler of the heating apparatus burst, demolishing the outbuilding in which it stood, and doing damage to the extent of $500.

No. 24. Saturday, January 6th.—Coton-in-the-Elms, Staffordshire. At St. Mary's Church the boiler of the heating apparatus burst, considerably damaging the premises.

No. 25. Saturday, January 6th.—High Barnet, Hertfordshire. At the Wesleyan Chapel the boiler of the heating apparatus burst during the night, doing some slight damage.

No. 26. Sunday, January 7th.—Turriff, Banffshire. Explosion in a dwelling-house, wrecking the kitchen and adjoining green-house, and injuring three servants.

No. 27. Sunday, January 7th.—London, Tulse Hill, Lambeth. Explosion in a residence, blowing out doors and windows, demolishing the range, and so severely injuring an elderly woman (the wife of the man in charge), that she died a week later. Verdict of the coroner's jury, "Accidental death." The jury added, however, that they thought all kitchen boilers should be fitted with safety-valves.

No. 28. Sunday, January 7th.—London, 13 Sussex Gardens. Explosion in a dwelling-house, wrecking the kitchen of this house and that of the adjoining one, blowing a hole in the wall between them eight feet by ten, killing the two-year-old son of the man in charge, and seriously injuring two other persons. Verdict of the coroner's jury, "Accidental death." In this case also the jury recommended that safety-valves be placed on boilers of this kind to prevent the recurrence of such explosions.

No. 29. Sunday, January 7th.—Preston, Beech Grove, Ashton-on-Ribble. Explosion in a dwelling-house, blowing out the range and severely injuring a boy.

No. 30. Sunday, January 7th.—Glasgow. Explosion at the Lady Artists' Club, while the family of the fireman was sitting at dinner, wrecking the kitchen, killing the fireman's wife and son, and severely injuring two other persons. As the occurrence was in Scotland, there was no coroner's inquest.

No. 31. Sunday, January 7th.—London, Battersea. At Mantua Street school the boiler of the heating apparatus burst, doing considerable damage.

No. 32. Sunday, January 7th.—Liverpool. At St. Saviour's Schools the boiler of the heating apparatus burst, damaging the building.

No. 33. Sunday, January 7th.—Dundee. At Gilfillan Memorial church the boiler of the heating apparatus burst, damaging the building, blowing out doors and smashing windows, and causing a panic among the children. Fortunately, however, none of them were injured.

No. 34. Sunday, January 7th.—Oldham, Delph. At the Wesleyan chapel the boiler of the heating apparatus burst, firing the chapel and burning it to the ground, the damage being estimated at $25,000.

No. 35. Sunday, January 7th.—Ludlow. At the Police Station the boiler of the heating apparatus burst while a constable was firing it, damaging the premises and injuring the constable.

No. 36. Monday, January 8th.—Darwen. At the Theatre Royal the boiler of the heating apparatus, situated under the auditorium, burst, wrecking the surrounding brickwork.

No. 37. Tuesday, January 9th.—Manchester, Withington. Explosion in a dwelling-house, wrecking the kitchen, blowing out a large portion of the gable end of the house, and severely injuring two women.

No. 38. Tuesday, January 9th.—Bridgenorth. At the Congregational chapel the boiler of the heating apparatus burst, wrecking the interior of the chapel, and seriously injuring two men who were repairing another heating apparatus close by.

This is a professedly incomplete list of the explosions of kitchen boilers and heating boilers, for the *five days* between *Friday*, January 5, and *Tuesday*, January 9, inclusive. It comprises no less than 38 explosions, all of them of boilers that were believed by their owners to be perfectly safe, on account of the low pressures they were supposed to carry. Twelve lives were lost, and thirty-three persons were injured.

Wild Camels in Arizona.

The camels now running wild in Arizona are the descendants of a small herd originally imported for use in the State of Nevada. In the early days of mining on the Comstock, long before there were any railroads in the Great Basin region, it was thought that camels might be profitably used about the mines, particularly in packing across the surrounding deserts, and twelve "ships of the desert" were accordingly purchased and brought to Virginia City. They were wanted for use in packing salt from the Salt Springs salt marsh to the Comstock reduction works. This salt deposit lies far out in a desert region, and to reach it many waterless stretches of sand and alkali had to be traversed.

The camels were able to cross all the deserts in perfect comfort, carrying heavy loads of salt and finding means of subsistence in the prickly and bitter plants and shrubs everywhere to be found in abundance. In short, the animals did as good work here in our deserts as they are able to do in any country in the world, but they were too slow. The camel may be fast enough for an Arab, but he is too slow for an American.

When the occupation of the camels as packers of salt was gone they were sold to some Mexicans, who used them for a time in packing wood down out of the mountains. The Mexicans took them up rocky trails into the rugged hills and used them the same as they used a mule — unmercifully. They soon killed three of the wretched beasts, and would have killed the remainder had not a Frenchman, who owned a big ranch on the Carson River, below Dayton, taken pity on the poor, abused creatures and bought the whole of them. This Frenchman had been in Algeria with the French colony, where he had developed an affection for the camel — probably owing the animal a debt of gratitude for having saved his life on some occasion. He had no use for the beasts, and therefore turned them out to roam the desert plains at will.

The animals, left to shift for themselves, soon waxed fat, and increased and multiplied. In a few years, from nine the herd had increased to thirty-six, old and young. The Frenchman then sold the whole lot to be taken down to Arizona to be used in packing ore down off a big mountain range. It was said there was a good smooth trail, but the animals found all the rocks and soon became footsore and useless, when all were turned adrift to shift for themselves. They have regained the instincts of the original wild state of their species and are very wary and swift. They fly into waterless wastes, impenetrable to man, when approached. Some of the old animals, however, occasionally appear in the vicinity of the settlements. Of late it is reported that the cattlemen have been shooting them for some reason, perhaps because they frighten and stampede their horses. No one knows how many camels are now running at large in the wilds of the Gila country, but there must be a great number. One is occasionally caught. Four years ago one was captured near Gila Bend that measured over nine feet in height. It appeared to be astray from one of the herds in that region.—*San Francisco Chronicle.*

The Locomotive.

HARTFORD, MARCH 15, 1894.

J. M. Allen, *Editor.* A. D. Risteen, *Associate Editor.*

The Locomotive *can be obtained free by calling at any of the company's agencies.*

Subscription price 50 *cents per year when mailed from this office.*

Bound volumes one dollar each. (Any volume can be supplied.)

Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

The *Report* for 1892 of the Badische Gesellschaft zur Ueberwachung von Dampfkesseln, of Mannheim, Germany, is at hand. It shows the association to be in a flourishing condition.

We desire to acknowledge a copy of Chief Engineer Sinigaglia's *Calcul de l'epaisseur des chaudières à vapeur.* This essay is very interesting, and we hope shortly to publish an extract from it.

The fourteenth volume of the *Transactions* of the American Society of Mechanical Engineers has been issued. It is much larger than usual, containing no less than 1,461 pages. It includes the reports of the 26th and 27th meetings, held at New York and Chicago, respectively, and constitutes a valuable addition to the literature of engineering.

The Hartford Steam Boiler Inspection and Insurance Company has recently secured the services of Mr. L. B. Brainerd, to act in the capacity of assistant treasurer. Mr. Brainerd, in earlier life, has had experience in the fire insurance business as general agent and adjuster, and also as secretary. For the past eight years he has been connected with the Equitable Mortgage Company of New York. He brings to his new position a wide and valuable experience in financial matters.

We have received from the D. Van Nostrand Company, of 23 Murray street, New York, a copy of Mr. Wm. Paul Gerhard's little book on *Gas Lighting and Gas Fitting.* The first edition of this book was published in 1887. The present edition is considerably enlarged. It includes an article on "Artificial Illumination and the Advantages of Gas," one on "Hints to Gas Consumers," and one on "Specification for Gas Piping." There is also a translation of the municipal rules and regulations regarding gas piping and gas fitting in the city of Munich, Germany. The volume is interesting, and should be useful. It forms No. 111 in Van Nostrand's Science Series, and the price is 50 cents.

From the same publishers we have also received a copy of the second edition of Crocker & Wheeler's excellent little book on *The Practical Management of Dynamos and Motors.* The first edition of this book was reviewed on page 136 of The Locomotive for 1892. The present edition is revised and enlarged, and includes a special discussion of the Thomson-Houston arc dynamo, by Mr. Horatio A. Foster. (205 pp. $1.00.)

MESSRS. John Wiley & Sons, of 53 East 10th street, New York, have favored us with a copy of Mr. H. C. Reagan's book on *Locomotive Mechanism and Engineering*. It is a first-class book, and we have read it with much interest. Mr. Reagan writes for the practical locomotive engineer, and his book is full of ideas and suggestions that ought to be useful. He gives special attention to accidents and break-downs, and as what he has to say on this subject is based on his personal experience and observation, his advice can hardly fail to interest all railroad engineers. The book is copiously illustrated. (296 pp. $2.00.)

PROFESSOR Alexander Ziwet has kindly sent us the second part of his *Elementary Treatise on Theoretical Mechanics*, the first part of which was noticed in the December issue of THE LOCOMOTIVE. The present volume contains an introductory chapter on dynamics, and the remaining chapters are devoted to statics. It is hardly too much to say that Prof. Ziwet's work bids fair to be the most important contribution to the subject of theoretical mechanics yet produced in this country. The present volume is fully up to the standard set by the first one; and this is the highest praise we could give it. (Macmillan & Co.)

Tiny Steam Engines at the Fair.

There were at least two exceedingly small steam engines on exhibition at the World's Fair. One of these was made by Mr. A. Muller, and loaned by him to the Waltham Watch Company, by whom it was placed on exhibition. It is exceedingly minute, and furnished about power enough to run a watch. A full-sized engraving of it was published in the *Scientific American* for January 13, 1894. We do not know the dimensions of the parts, but the engine is well-proportioned, and is said to be made in the same way as the larger ones that we are all familiar with.

The other pigmy engine was exhibited by Max Kohl, of Chemnitz, Germany, by whom it is called "the smallest steam engine in the world." The dimensions of this microscopic power plant were given in millimeters, and we reproduce them below, both in millimeters and in fractions of an inch.

Length of cylinder, ...	5.5	mm.	=	0.22	in.
Diameter of cylinder, ...	2.0	"	=	.08	"
Diameter of flywheel, ...	10.0	"	=	.40	"
Width of flywheel, ...	1.5	"	=	.06	"
Length of boiler, ...	20.0	"	=	.80	"
Diameter of boiler, ...	8 5	"	=	.34	"
Bore of main steam pipe, . . .	0.4	"	=	.016	"
Length of slide valve, ...	1.8	"	=	.072	"
Width of slide valve, ...	1.7	"	=	.068	"
Length of steam ports, ...	1.3	"	=	.052	"
Width of steam ports, ...	0.2	"	=	.008	"

The whole apparatus goes inside an English walnut shell, which is hinged to form a case for it. It was mounted in a glass tube, which was provided with a lens at the upper end, by means of which an enlarged and very good view of the engine and boiler could be had. The engine is horizontal, with the steam-chest on the side. It was fitted with a common ball governor, and the boiler has a lever safety-valve. The workmanship was excellent in every respect.

Foreign Boiler Explosions.

The United States does not have a monopoly in boiler explosions, though of course we hear more of those that occur in this country than we do of foreign ones. Some of the more notable explosions that have occurred recently in other countries are given below.

On January 26th a disastrous explosion occurred in France, at Boulogne sur Seine. The boiler was in a laundry in that city. Several persons were killed and a number of others were buried in the ruins. Many persons were also seriously injured.

A dispatch from Rio de Janeiro, dated February 24th, says that the destruction of the insurgent transport *Mercurio*, which was sunk by the fire of the guns of the government battery at Ponta Madame, is said to have resulted in considerable loss of life to the rebels. The shots which caused the vessel's destruction penetrated her boiler, which burst and killed a number of the insurgents. The ship then caught fire and many of the injured are said to have been burned to death. The transport was still burning fiercely when she sank.

The explosion of a boiler in the iron works at Alexandrovski, Russia, on February 26th, resulted in the death of twenty-five men, and the injuring of many others. Hundreds of workmen are employed near the scene of the explosion, and it was considered marvelous that more were not killed. The boiler let go without a moment's warning, and the fragments flew in every direction. A panic seized the workmen, and those not killed or injured where they stood ran for their lives. Several were struck by the flying fragments as they were running, and were instantly killed. The mill and most of the machinery were badly wrecked.

The Moon of Romance.

The novelists will not leave "the young moon" or "the crescent moon" alone, and three times out of four they contrive to get it into the wrong place. How to explain the conviction which haunts the minds of so many of them, that the crescent moon may be seen almost any fine evening rising gracefully in the east, is altogether beyond us. The point seems to be one for psychologists. Here is a thing that never was seen since the world began; and yet a number of otherwise sane gentlemen are firmly persuaded that it is a regularly recurring natural phenomenon. Surely the philosophy of this hallucination deserves investigation. The last case that has come under our notice is a well-written story called "A Comedy of Masks," by Ernest Dawson and Arthur Moore. Two friends are sitting out one summer evening, looking over the Thames, and the story goes on: "By this time the young moon had risen, and its cold light shimmered over the misty river." A novelist need not be an astronomer, but he should at least try to draw from Nature, and should not pretend to have seen the young moon rising at the very hour when it was being packed off to bed. Some day, perhaps, a little acquaintance at first hand with the broadest facts of Nature will be thought a requisite for writing a good novel, but the time is not yet. Meantime, if our novelists would try to bear in mind that the young moon, like other young things, goes to bed early — that Nature does not trust it out late at night — they might get into the way of seeing it at the right time and in the right place, and not treat us to "cold shimmers" that are only moonshine in the least favorable sense of the term.

Since the foregoing was put in type our attention has been called to a precisely similar blunder in an article entitled "Notes from a Marine Biological Laboratory," written by a man of science and a college professor, and printed in the February number of this magazine. In the light of what has previously been said, the situation, we must confess, is decidedly awkward, and not at all to the credit of our editorial scrutiny. Yet, while freely admitting that the case is far less excusable than the one cited above, we are still inclined to regard it as an even more emphatic admonition that writers, and particularly writers on scientific subjects, are under obligations to know what they are talking about, and should also be able to subordinate their poetical ambitions to the requirements of truth.— *Popular Science Monthly.*

[The passage referred to above, in the February issue of the *Popular Science Monthly*, is as follows: "It was a beautifully clear and starry night when we sailed into Windward passage. The gray mountains of Cuba outlined against the northern horizon were slowly fading from view, when the crescent moon arose out of the waves in the east." This passage occurs on page 449, and the article was written by Prof. William S. Windle.— Ed. Locomotive.]

Notes from an Inspector.

An inspector in our northwestern department sends a few notes concerning some things that have recently come under his observation; and as they may interest readers of The Locomotive, we give them below:

"The first case I want to mention relates to overheating of the furnace plates of two boilers in this vicinity. They were each sixteen feet long and 60 inches in diameter, with 44 four-inch tubes, and a man-hole in the front head, under the tubes. These boilers had just been put in, and for ten days they were run very light. They were then started on the regular work, which did not by any means push them to their full capacity. They were run night and day, and their heaviest work was at night. One morning, after they had been running on regular work for about three weeks, they were both found to be badly bagged on the bottom, directly along the front line of the bridge-wall. The bags ran clear across the boilers, and two-thirds of the way up to the water-line. The bulges were greatest at the bottom, where they amounted to about three inches. They extended forward from the bridge-wall for a distance of three or four feet, so that I estimated their area to be about sixteen square feet in each boiler. As soon as I was called on to make an inspection (about 10 A. M.), I went immediately to the boilers and found them in the condition I have described, a new bottom being required in each. One of them was still running, but the fire had been drawn from the other. I had them blow off the boiler that was out of use, so that I could see its condition, inside, just as it was, and before any washing was done. I found the bottom of the boiler heavily covered with a gummy, greasy sediment, about a quarter of an inch thick. It seemed to be organic in nature, and I concluded that it came from the radiators and piping, all of which were new. It would be impossible for any water to get through it, so as to come in contact with the sheets; and the heaviest or thickest part of it was where the sheet was bagged the worst. In the rear part of the boiler, from the middle of the bridge-wall to the back head, there was a heavy coating of oil, both on the sheets and on the tubes.

"It was easy to see the cause of all the trouble. The building was new, and was heated from top to bottom by exhaust steam from the engines and pumps. They had flooded the engines and pumps with oil, and this oil had been carried all through the building by the exhaust steam, and had been emptied into the boilers together with the sand and other foreign materials contained in the radiators and pipes. (Of course there is always more or less oil and other matter in new work of this kind.) Their mistake was, in not passing all the returns into the sewer for about four weeks, and in being too lavish with oil in the engines and pumps. If they had opened the boilers a couple of weeks sooner, or if they had had their boilers properly inspected, their attention would have been called to the trouble before it was too late. An inspection would have been of especial value to them, as there are many things that may give trouble in starting a new plant. These people had all the best modern appliances, including water-filters and an oil separator; but these were not sufficient to prevent the accident I have described.

"Another thing which I frequently notice in making calls in the way of external inspections, is the neglect of the water connections between the gauge-glass and the boiler. Every engineer is supposed to give his closest attention and care to these connections, but I find that they are sadly neglected by some of the oldest and most experienced engineers. I called at a plant a short time ago, where the engineer had had some years of experience. He had been in this plant for a year. I asked him to blow out the water glass; and after waiting some time for the water to return, I had concluded that it was not going to. Presently, however, it came in sight, and after a considerable time it came up to the proper height in the glass. I asked him to blow it out again, thoroughly; and with my watch in hand I timed its return. It took over five minutes for the water to come in sight. The connection between the boiler and the glass was of one-inch piping. I asked the engineer how large he thought the opening through this pipe was. He said he had not thought about that. It was plain that this trouble had been going on for weeks, and yet he had not discovered how long it took the water to get back into the glass, nor had he given the matter any thought or consideration. If the water only *got* back, that was sufficient. I told him the opening could not be much larger than a knitting needle, and then he began to get his thoughts together. They had an extra boiler, and the one thing on this engineer's mind, for a little while, was to get around fast enough, till he could get this extra boiler ready and shut the other one off and clean out the pipe connections to the water glass. Another case, very similar to this, came under my notice recently, except that it was worse. There were *six* boilers in this battery, and four of the six were in a condition fully as bad as that I have just described; yet the engineer in charge had been in this plant for years, and considered himself well up in engineering.

"Another point I want to speak of, is the importance of having the piping free, between the *steam* gauge and the boiler. Such pipes are often long and small, and with a number of elbows in them. I am frequently called upon to test steam gauges which are all right when the pipes are cleaned out."

STEAM boiler and engine statistics gathered in the German Empire show that, at the beginning of 1893, there were in operation in that country 81,000 stationary boilers and 78,936 stationary engines.— *Power.*

The Cocoanut Tree.

The cocoanut palm is a magnificent plant, well named a "prince of the vegetable kingdom," with tall, slender, columnar stem eighty or one hundred feet high, and rich pale yellow-green leaves which are thirty or forty feet long, and flutter and rustle with every breath of wind. The cocoanut grows only near the shore, where its roots, penetrating the sandy soil, may drink freely from clear, underground springs. Of all trees it is the most useful to man, furnishing food, shelter, and employment to hundreds of thousands of the human race. In tropical countries, especially in southern India and Malaya, the cocoanut supplies to whole communities the chief necessities of life. Every part is useful; the roots are considered a remedy against fevers; from the trunk, houses, boats, and furniture are made; the leaves furnish the thatch for houses and the material from which baskets, hats, mats, and innumerable other articles are made; the network of fibers at their base is used for sieves and is woven into cloth; from the young flower-stalks a palm wine, called toddy, is obtained, from which arrack, a fiery alcoholic drink, is distilled. The value of the fruit is well known. From the husk, which is called coir, commercially, cordage, bedding, mats, brushes, and other articles are manufactured. In the tropics, lamps, drinking vessels, and spoons are made from the hard shells. The albumen of the seed contains large quantities of oil, used in the East for cooking and illuminating; in Europe and the United States it is often made into soap and candles, yielding, after the oil is extracted, a refuse valuable as food for cattle, or as a fertilizer. In some parts of the tropics the kernel of the seed forms the chief food of the inhabitants. The cool, milky fluid which fills the cavity of the fruit when the nut is young affords an agreeable beverage, and the albumen of the young nut, which is soft and jelly-like, is nutritious and of a delicate flavor. As might be expected in the case of a plant of such value, it is often carefully and extensively cultivated in many countries, and numerous varieties, differing in the size, shape, and quality of the fruit, are now known. The cocoanut is propagated by seeds; the nuts are sown in nursery beds, and at the end of six or eight months the seedlings are large enough to plant. The plants are usually set twenty-five feet apart each way, in carefully prepared beds filled with rich surface soil. Once established, a plantation of cocoanuts requires little care beyond watering, which is necessary in its earlier years to insure a rapid and vigorous growth. In good soil the trees usually begin to flower at the end of five or six years, and may be expected to be in full bearing in from eight to twelve years. Thirty nuts from a tree is considered a fair average yield, although individual trees have been known to produce an average of three hundred nuts during a period of ten years. An application of manure increases the yield of the trees, although probably the value of the additional crop obtained in this way is hardly large enough to justify much expenditure. In recent years the cocoanut has been cultivated on a very large scale in British Honduras, Jamaica, and other parts of Central America, as well as on the northern coast of South America and the West Indies. The consumption of cocoanuts in the United States has become very large, as many as twenty millions being imported to this country every year. They are brought largely in steamers with other cargoes, although there are sailing vessels engaged in this trade exclusively, and last month two schooners discharged in this city, respectively, 170,000 and 260,000 nuts.

More than one-half of all the cocoanuts imported are bought by the confectioners, a single firm in New York using as many as forty thousand a month, and it is possible to fill this large standing order because importations are made all the year round. Of the remainder the larger portion goes to the dessicating establishments, while only a few are now sold in the stores in their natural condition. — *Garden and Forest.*

The Locomotive.

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NEW SERIES — VOL. XV. HARTFORD, CONN., APRIL, 1894. No. 4.

A Case of Defective Riveting.

The driving of rivets is such a comparatively simple operation, that it might be supposed that it would be almost always well done. This is far from being the fact, however, and bad riveting is one of the commonest defects reported by our inspectors. The rivets may be too short, or too long, or too small; they may have heads that are too flat, or they may have projecting "fins," or they may not fill the holes, or the holes may not come "fair" with one another. There are many ways in which riveting may be bad.

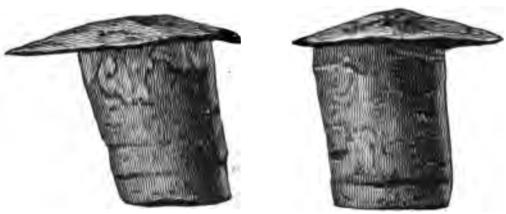
A case that recently came to our notice seems to deserve special mention. The rivets in question were in a vertical pulp digester, 10 feet in diameter, and 30 feet high, which was to be so constructed as to be safe under a pressure of 90 pounds to the square inch. The plates were of steel, ⅝-inch thick, united by lap joints, which were triple riveted on the straight joints, and double riveted on the girth joints. The pitch of the

SOME DEFECTIVE RIVETS.

rivets in each case was 3½ inches, and the distance between the parallel rows was 2 inches. The rivets were ¾-inch in diameter.

Before the digester was accepted, we were called upon to inspect it and pronounce upon its safety. The inspector found the rivets "driven very low"— that is, the heads were entirely too flat, as shown in the accompanying wood-cuts, which are made directly from photographs of the rivets. He had a number of these rivets taken out, and found that the holes in the two sheets did not come opposite one another fairly. This defect is a common one, and it is very serious, both because it reduces the shearing area of the rivet, and because it greatly increases the diffculty of making the rivets fill the holes perfectly. A shop that turns out work of this kind is particularly censurable, not only because the work itself is poor and weak, but also because the defect is not easy to discover, after the rivets are in place, and the owner of the boiler is therefore likely to be deceived by a fair external appearance, and to carry more pressure than the boiler can safely withstand.

The inspector also found that the heads were not driven evenly over the holes, the centers of the heads often lying well towards the side of the rivet. This defect, although not so dangerous as the unfairness of the holes, would not be tolerated in a good shop having any pretentions to turning out first-class work. It is very easily detected, even by one who has had little experience in inspecting; and there is no excuse for it, whatever. The rivet holes were not countersunk, as they should be in all good work; and, taking everything into consideration, we think this case presented the finest example of notoriously bad work that we have seen in some time. The only thing that could be done to it, in the way of improvement, would be to cut out all the rivets, ream out the holes until they should be true, and rivet them up again with larger rivets. The most reprehensible thing about the job, perhaps, is that the builder used rivets that he knew to be *too short*. At least, we presume he knew them to be so, for any one who had the smallest idea about the business would know it. A boiler ten feet in diameter, to carry 90 pounds of steam, and with five or six men working about it, cannot be built too carefully; and any such reckless performance as putting in rivets that are too short and too small, comes dangerously near being criminal negligence.



Some Defective Rivets.

The joint used in this digester is far from being beyond criticism. To begin with, a *lap* joint should not be used at all: a *butt* joint would be much safer, and better in every way. Taking the tensile strength of the plate at 60,000 pounds per square inch, and the shearing strength of the rivets at 38,000 pounds per square inch, a little calculation will show that in the joint that was actually used the rivet area is far too small, so that with $\frac{3}{4}$-inch rivets and a factor of safety of 5, the safe working pressure is only about 56 pounds. If a triple riveted lap joint were used at all, the rivets should be an inch in diameter (holes $1\frac{1}{16}$ inch), and the pitch should be about $3\frac{3}{4}$ inches. This joint gives an efficiency of 72 per cent., and a safe working pressure (with a factor of 5) of just 90 pounds per square inch. But a double welt butt joint is the proper thing for this case.

Inspectors' Report.

February, 1894.

During this month our inspectors made 7,347 inspection trips, visited 15,515 boilers, inspected 5,769 both internally and externally, and subjected 456 to hydrostatic pressure. The whole number of defects reported reached 10,273, of which 1,333 were considered dangerous; 47 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	708	52
Cases of incrustation and scale,	1,601	63
Cases of internal grooving,	69	4
Cases of internal corrosion,	586	44
Cases of external corrosion,	771	58
Broken and loose braces and stays,	189	68
Settings defective,	300	28

Nature of Defects.	Whole Number.	Dangerous.
Furnaces out of shape,	410	17
Fractured plates,	296	62
Burned plates,	193	20
Blistered plates,	218	7
Cases of defective riveting,	1,372	74
Defective heads,	102	27
Serious leakage around tube ends,	1,640	487
Serious leakage at seams,	465	34
Defective water-gauges,	374	92
Defective blow-offs,	148	35
Cases of deficiency of water,	18	9
Safety-valves overloaded,	71	37
Safety-valves defective in construction,	134	37
Pressure gauges defective,	512	47
Boilers without pressure gauges,	18	18
Unclassified defects,	78	13
Total,	10,273	1,333

Boiler Explosions.

FEBRUARY, 1894.

(32.) — On February 2d, the boiler exploded in Warren's mill, at Byer's Corners, near Ottawa, Ont. The engineer, a Swede named John Possette, was injured so seriously that he is not expected to live. The boiler is said to have been found "about three acres from where it was stationed," however far that may be.

(33.) — A boiler exploded on February 2d in E. R. Ulrich & Son's elevator, at Dawson, Ill. Jerry Baugh and his little boy, who were in the elevator at the time, were scalded badly. It was at first believed that both would recover; but, on February 11th, the boy was taken with tetanus, and, at last accounts, it was considered certain that he would die.

(34.) — On February 9th, a boiler belonging to Mr. Isaac Atyeo of Ripley township, near Norwalk, Ohio, exploded. Mr. Mack Atyeo was killed, and Vernon Atyeo and Frederick Guess were badly scalded and otherwise injured, but will recover.

(35.) — Two boilers exploded on February 10th at Eckley No. 10 Colliery, near Hazleton, Pa. There were four men at work in the building at the time, and they had remarkable escapes from death. The men were firing when the first explosion took place. This carried away the rear portion of the boiler-house, and scattered hot coals all about the workmen. They made a hasty exit, but had hardly emerged through the door when another explosion occurred, even more violent than the first. This carried away the remaining portion of the boiler-house and lodged it against the bank supporting the railroad, some distance away. The force with which it struck the bank tore the rails from their fastenings and twisted them so badly that all traffic was suspended for several hours.

(36.) — An iron flange at the "dead end" of one of the main steam pipes in the trolley power-house of the Philadelphia Traction Company, at Thirteenth and Mount

Vernon streets, Philadelphia, Pa., blew off on February 10th, and Michael Welsh, George Gibbs, James Manders, Henry Jones, and George Simpson were injured.

(37.) — On February 8th, a boiler exploded at the Primrose Colliery, operated by C. Nevels & Co., at Mahanoy City, Pa. The exploded boiler was one of a nest of twelve, all of which were disturbed by the explosion. The fireman is said to have had a "premonitory warning" of the coming event. At any rate, he made tracks for a place of safety, and escaped injury.

(38.) — A boiler explosion occurred on February 12th at what is known as the "Q shaft," at Braidwood, near Spring Valley, Ill. A flue collapsed in one of a battery of three boilers, and the boiler-setting and boiler-house were badly damaged. The fireman saw signs of the impending collapse, and his warning enabled those in the boiler-house to get out in time to escape injury. John Harrop, however, who was shoveling slack into the building from a car alongside, failed to hear the fireman's alarm, and he was severely scalded about the back and sides.

(39.) — A switch engine was pulling a train of cars through the Santa Fé yards at Temple, Tex., on February 12th, when its boiler exploded. Engineer Coleman, Fireman Cheatham, Foreman Vogler, and Switchman Hoges were riding on the engine at the time. Coleman was badly scalded and bruised; he will die. Vogler was similarly injured, and will also die. Hoges was blown through the cab window to a distance of 150 feet; he was injured internally, and will die. Cheatham was badly scalded, and his right leg was cut off at the knee; there is no hope of his recovery. The crown sheet of the locomotive was blown through a car, making a complete wreck of it.

(40.) — A boiler exploded on February 13th at Farios Bros.' cork factory, Gibraltar, Ind.

(41.) — The boiler of a large traction engine belonging to W. J. Keeler of Buffalo, N. D., exploded nine miles southwest of that place on February 14th, demolishing the building in which it was used for grinding feed. The engineer was outside at the time, and escaped injury.

(42.) — A boiler exploded on February 15th in B. A. Lockwood & Co.'s elevator, at Kelley, Iowa. John Tanner, the engineer, was blown to pieces, and William Sells was fatally injured.

(43.) — On February 15th a boiler, belonging to James Snyder, exploded at Benton, Ohio. Fred Lehman was hurled against a fence 50 feet away, and fatally injured Snyder's son was also badly injured.

(44.) – John Thompson was fatally injured on February 12th by the explosion of a pumping engine boiler in the Matthews mines, near Cambridge, Ohio.

(45.) — A boiler exploded on February 17th in the new flour mill at Marquette, thirty miles west of Winnipeg, Manitoba. The engine-house was blown to atoms, machinery was hurled in all directions, and one end of the mill was entirely demolished. John Reid, who was running the engine at the time, was instantly killed.

(46.) — A boiler exploded on February 17th in the residence of Herman Burgander on Dana Place, Wilkesbarre, Pa. The damage was slight.

(47.) — A boiler used in the quarry at Squantum, Mass., belonging to the city of Boston, exploded on February 17th. Felix McConn, the engineer, was fearfully burned and scalded, and another man received lesser injuries. The boiler was blown into the air, and was found nearly a quarter of a mile from its original position.

(48.) — By a slight explosion in the power-house of S. N. Breed & Co., at Lynn, Mass., on February 17th, one man was badly scalded, and a fire was started which did considerable damage.

(49.) — On February 19th, a boiler exploded on the Laurel Farm plantation, near Houma, La. John Clement, Wiltz Rollins, and George McKinner were killed, and a brother of George McKinner was fatally injured. Joseph Martin and two boys named Matthews were also badly scalded.

(50.) — A boiler exploded on February 19th in the basement of a four-story brick building on Sixty-third Street, Chicago. The first floor was shattered by the explosion. The boiler was used for heating purposes.

(51.) — Samuel Johnson, George Washington, William Franklin, Alexander Franklin, and one other man, were killed on February 21st by the explosion of a boiler in the oil mill of Messrs. Freeman & Hayne in Compte, La. Several others were injured The building in which the boiler was located was totally destroyed.

(52.) — On February 21st, Andrew Dahringer was severely injured by the bursting of a boiler at the Hoopes & Townsend Works at Philadelphia, Pa. He was scalded about the face, leg, arms, and chest, and some of his ribs were broken. His condition is critical.

(53.) — A boiler exploded in a grain elevator in Sangamon County, Ill., on February 22d. Two men were badly scalded.

(54.) — Word is received from Dodge Center, Minn., under date of March 1st, saying that "the tow mill started up this week, but the boiler blew out and busted, and work is suspended again." The tow-mill people have our sympathy.

(55.) — During the progress of a fire in a business block owned by the Blythe estate in San Francisco, Cal., on Februrary 26th, a boiler in the basement of the "Golden Rule Bazar" exploded with a loud report, sending the debris in all directions. Fortunately nobody was hurt.

(56.) — The boiler of freight engine No. 1210, on the Baltimore & Ohio Railroad, exploded at Muzam's Mills, W. Va., on February 28th. Engineer Stevenson, Fireman Law, and Brakeman McCue were terribly injured, and later advices state that both Stevenson and Law died from their injuries, and that McCue cannot recover. The train was derailed, the wreck caught fire, and twelve cars were destroyed.

(57.) — Five men were injured on February 28th by the explosion of a boiler in Chidester's mill, near Plum City, not far from Durand, Wis. The injured men will recover. No further particulars have been received.

In a recent lecture on "Photometry," Captain Abney showed, in an ingenious way, the existence of solid particles of carbon in a candle or gas flame. A ray of sunlight was passed through a nicol prism, and focussed on the flame. The path of the beam of sunlight can be readily seen, when the observer looks at right angles to it. The nicol can be so placed, however, that the beam in the flame is invisible; and this proves, by a well-known principle in optics, that there is a multitude of finely-divided *solid particles* in the flame.

Finding of the Areas of Irregular Figures.

We have received the following communication from Mr. Thomas L. Hadley of Woonsocket, concerning the determination of the areas of irregular figures: "I notice that you say in The Locomotive for January, 1890, that 'the most satisfactory way to calculate the area of a segment is that given in The Locomotive for December, 1886. This method is exact, but it requires the engineer or inspector to have the table with him whenever he wishes to calculate a segment.' Here is another method for finding the area of a segment. It is not original with me, howevèr. I believe that the idea came from France, where it was used to find the average pressure of an indicator card. I have applied it also to the determination of the areas of segments and of irregular figures. Suppose, for example, we consider a boiler 66 inches in diameter, in which the upper row of tubes is 26 inches from the top of the shell. Suppose we allow 3 inches out for the flange to support, and 2 inches out for the tubes to support. This leaves a segment 21 inches high, of a circle 60 inches in diameter. To determine the area of this segment, first draw a diagram of the boiler on a scale of one inch to the foot, as shown in Fig. 1. Then find the area of the whole head of the 66-inch boiler. Divide this by 2, which gives the area of half the head. Bisect Fig. 1, as shown by the horizontal diameter, as only half of the diagram is needed to do the problem. Now *cut out* the upper half of the diagram carefully, and weigh it. This piece in the diagram I send you, weighed 12.3 grains. Then *cut out the segment* from this piece, and weigh that also. You will find that the segment weighs 6.35 grains. Then make a proportion as follows:

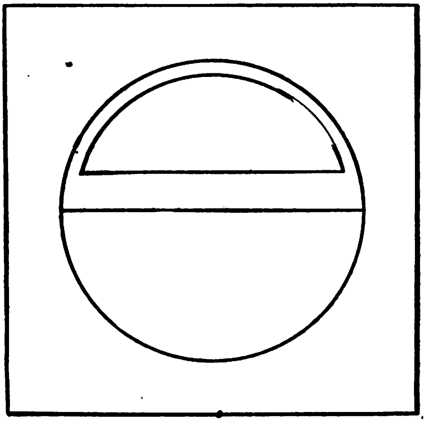
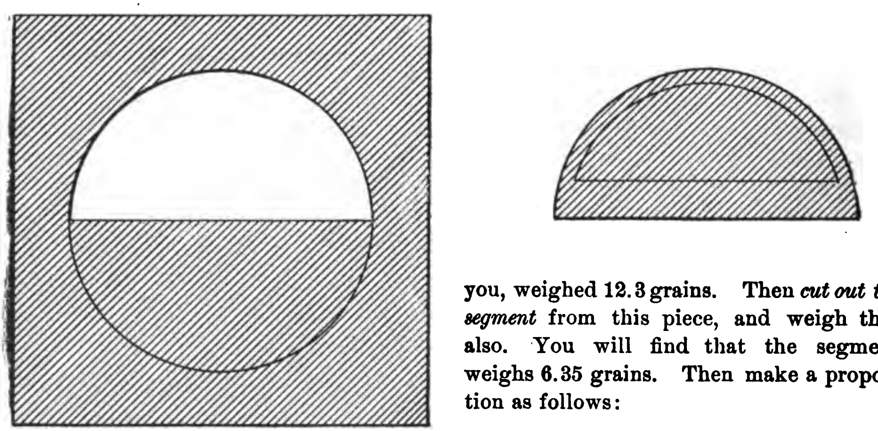


Fig. 1.— Area of a Segment.

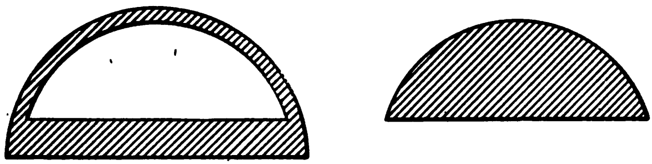


Figs. 2 and 3.— Area of a Segment.

12.3 : 6.35 :: 1710.6 (area of half the head) : 883.1

From which we conclude that the area of the segment is 883.1 square inches.

"The area and average pressure of an indicator diagram may be found in the same way. Erect perpendiculars from both ends of the atmospheric line, as in Fig. 6. (Be sure they are square with this line.) Then draw a horizontal line as shown at *AC*. Next measure the height from *A* to *B* by a scale to correspond with the spring used in taking the indicator diagram. This would be the average pressure in the engine, if tak-

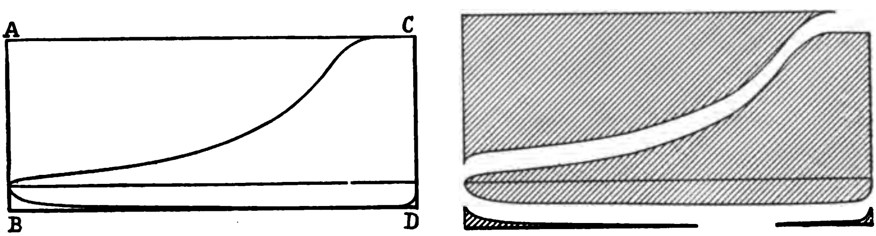


Figs. 4 and 5.—Area of a Segment.

ing steam full stroke and working theoretically. Cut out the rectangle *ABCD*, and weigh it as before. The result, with the card I send you, was 9.7 grains. Next, cut along the line made by the pencil of the indicator, and weigh the piece so obtained. (I found its weight to be 4.45 grains.) Now the height *AB*, in this case, was found to be 81 pounds, we have the proportion

9.7 : 4.45 :: 81 lbs. : 37.2 lbs.

From which we conclude that the average effective pressure, as shown by the card, was 37.2 lbs. per square inch. To find the area of the card, when we know the average pressure, we first find the average height by dividing the average pressure by the scale of the spring used, which in this case was 40. Thus: $37.2 \div 40 = .93$ in. Then, by



Figs. 6 and 7.—Indicator Cards: Finding Area and Average Pressure.

direct measurement, we find the length of the card to be 4.90 inches. Hence the area is $4.90 \times .93 = 4.56$ square inches. (I tested this result by the planimeter, and found it to be correct.)

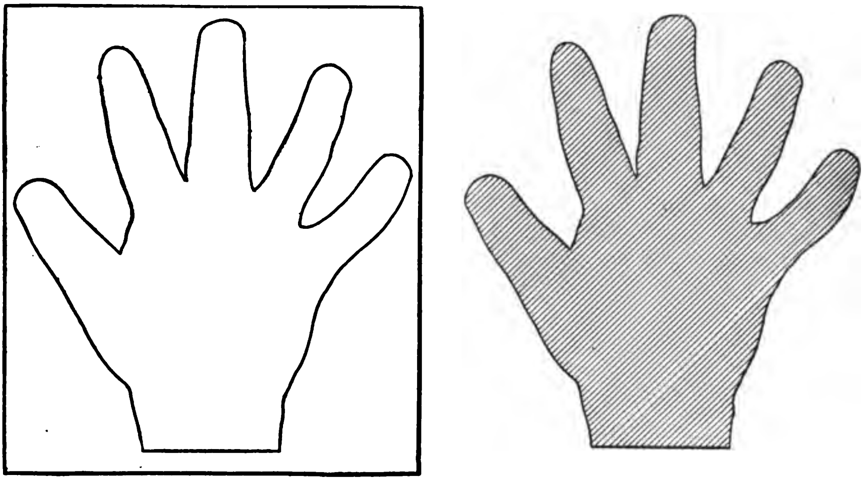
"I send you one more example of the application of the method to an irregular figure, choosing for this purpose the figure given in Fig. 8. The length of the rectangle *ABCD* is $5\frac{11}{32}$ inches, and its width is $4\frac{17}{32}$ inches; its area, therefore, is 24.21 square inches. Upon cutting out this rectangle, I found it to weigh 23.75 grains. Then, cutting out the part whose area is required, I found it to weigh 11.4 grains. The proportion in this case is

23.75 : 11.4 :: 24.21 : 11.62.

Hence we conclude that the area of the figure in question is 11.62 square inches. If you consider this method of finding areas to be of any value, you are welcome to use it in The Locomotive."

Mr. Hadley's method, although interesting, is not so new as he imagines it to be.

We do not know with whom it originated, but it was certainly used in Galileo's day. At that time the curve that geometers call the "cycloid" was attracting considerable attention, and many attempts were made to discover a rule for finding the area of cycloids. Galileo was interested in the problem, among others, but he found the mathematical difficulties involved in it to be too great for him to overcome. He therefore drew a cycloid on paper, cut it out, weighed it, and compared the result with the weight of the "generating circle," as cut from a similar piece of paper. We do not remember his precise result, but our impression is that he found the area of the cycloid



Figs. 8 and 9.—Finding the Area of an Irregular Figure.

to be 3¼ times the area of the generating circle: the *true* ratio, as has since been shown, being exactly 3. In recent times the method has largely passed out of use, the planimeter being used instead. Mr. Proctor used the "weighing method," however, to determine the proportion of land to water on the surface of the planet Mars. He constructed a special map of Mars for this purpose, and cut out the continents and islands, and compared them with the entire surface by weighing them. The chief objection to the process is its inaccuracy. The weighings must be performed with considerable precision, and this requires the use of a delicate balance, and considerable manipulative skill. Moreover, the paper used for the purpose must be of uniform thickness and density, or the relative weights will not represent the relative areas. This condition is not so easy to fulfill as might be imagined. Drawing paper that has been moistened and stretched on a drawing board so as to make it lie flat, is wholly unsuitable, as may easily be shown by comparing known areas by means of it. In all cases areas to be compared by weighing should be cut from the *same sheet of paper*, and the weighings should be performed as quickly as is consistent with accuracy; for paper is a hygroscopic substance, and the amount of moisture it contains (and consequently its weight) varies with the condition of the air.

In reply to many inquiries, we beg to say that the Eleventh Census did not include statistics of the steam power in the United States.

The Joule Memorial Statue.

Manchester, England, may well be proud of having been the home of two such famous men of science as John Dalton and James Prescott Joule. A beautiful statue of Dalton, who laid the foundation of the atomic theory in chemistry, has adorned the vestibule of the town hall of that city for some years; and, on December 7, 1893, a statue of Joule was unveiled in the same place, and the two philosophers now stand face to face. The unveiling of the Joule statue was performed by Lord Kelvin (Sir William Thomson), who was peculiarly fitted for that function, both on account of his ability and renown as a scientist, and because he had worked with Joule many years before, when the theory of the conservation of energy was coming out of obscurity and into its present form. The Literary and Philosophical Society of Manchester had the distinguished honor of being really the cradle of Joule's work. From very early days he kept constantly in touch with that society. Many of his most important papers were first given to the world there, and during the last years of his life he was an almost constant attendant at its meetings. Joule's life was remarkably replete with discoveries, but undoubtedly the one for which he will longest be remembered was his "great fundamental discovery" of the mechanical equivalent of heat. "It was not merely by a chance piece of measurement that he stumbled on this result, which was afterwards found to be of great value. It was measurement, rigorous experiment and observation, and philosophic thought all around the field of physical science that made this discovery possible. Very early indeed in his working time Joule brought out the mechanical equivalent of heat, and in a paper read before the British Association at Cork in 1843, and afterwards published in the *Philosophical Magazine*, he gave the famous number '772.' Six years later a second determination gave him the same result, and twenty-five years later he made a third determination, which gave him the final and corrected result, '772.56.'" Lord Kelvin went on to say that he could never forget the meeting of the British Association at Oxford in the year 1847, when, in one of the sections, he heard a paper read by a very unassuming young man, who betrayed no consciousness in his manner that he had a great idea to unfold. He (Lord Kelvin) was greatly impressed by the paper. At first he thought it could not be true, because it was different from Carnot's theory; and, after the meeting, he had a long and thoroughly discursive talk on the subject with Joule, and obtained ideas he had never had before. He afterwards had the great pleasure and satisfaction of making experiments along with Joule, which led to some important results in respect to the theory of thermodynamics. This, he said, was one of the most valuable recollections of his life, and was, indeed, as valuable a recollection as he could conceive in the possession of any man interested in science. Joule's initial work was the very foundation of our knowledge of the steam engine and steam power. Taken along with Carnot's work, it had given the scientific foundation on which all the great improvements since the year 1750 have been worked out, not in a haphazard way, but on a careful, philosophical basis.

After congratulating the city of Manchester on the proceedings of the day, and expressing his emotions at beholding once more the face of his old friend (he pronounced the statue to be "a most admirable likeness"), Lord Kelvin asked to be allowed to congratulate the sculptor also, for the great beauty and the great success of his work. Sir Henry Roscoe, in moving a vote of thanks to Lord Kelvin for his address, mentioned that for thirty years he himself sat at the feet of Joule, whom he might, therefore, claim, in some sense, as his scientific father. Few cities in the world, he said, could boast of two greater men than Dalton and Joule.*

* For the facts presented in this article we are indebted to *Nature*.

The Locomotive.

HARTFORD, APRIL 15, 1894.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

Subscription price 50 *cents per year when mailed from this office.*

Bound volumes one dollar each. (*Any volume can be supplied.*)

Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

WE beg to acknowledge the receipt from Mr. Rufus R. Wade, chief of the Massachusetts District Police, of a copy of his *Report* for the year 1893. Mr. Wade says: "I have endeavored to incorporate herein all the information which tends to show what has been accomplished by the District Police during the year covered by this report, which includes not only the prevention of crime and the detection and punishment of criminals, but also the enforcement of the numerous laws relating to the inspection of factories, workshops, and public buildings." This was no small task, as the force of men under Mr. Wade's direction numbers thirty-eight, "of whom twenty-six are detailed for service in the inspection department, eleven designated for detective duty, and one for the inspection of uninsured steam boilers, and to inquire into the ability and competency of the engineers in charge thereof"; but it has been accomplished in a praiseworthy manner.

Navy Department Rules for Bumped Heads.

On page 40 of the *Proceedings* of the forty-first annual meeting of the Board of Supervising Inspectors of Steam Vessels, held in January, 1893, we find the following report of the committee on Boilers and Machinery: "The Committee on Boilers and Machinery having had under consideration the communication of the Supervising Inspector of the Second District, presented to the board by the Supervising Inspector-General on the 31st day of January, 1893, relating to amending the rules to regulate the pressure for 'bumped heads' for marine boilers, beg leave to report as follows: We have carefully considered the proposed amendment and report the same back and recommend its adoption as follows: [To find the] pressure allowed on 'bumped heads,' multiply the thickness of the plate by one-sixth of [the] tensile strength, and divide by the radius to which [the] head is bumped; which will give the pressure per square inch of steam allowed." This report was adopted, and the same rule is repeated, on page 165, among the "General Rules and Regulations." In the *Report* of the proceedings of a special meeting of the Board of Supervising Inspectors, held in May, 1893, however, this rule was amended, on motion of Gen. J. A. Dumont, thus: "*Be it further resolved,* That the rule for bumped heads of boilers adopted at the last meeting of the board, and printed on page 8 of Circular No. 25, 1893, be amended to read as follows: *Pressure allowed on bumped heads.*—Multiply the thickness of the plate by one-sixth of the tensile strength, and divide by six-tenths of the radius to which [the] head is bumped; which will give the pressure per square inch of steam allowed." This latter form of the rule is also given on page 4 of the *Circular* issued by Gen. Dumont under date of February 19, 1894.

We quote these rules in order to call our readers' attention to them, and prevent, so far as we can, such confusion as might possibly arise from overlooking the early repeal of the first rule.

An Inspector's Strange Experience.

An inspector in our northwestern department writes to us concerning an experience that recently befel him, as follows: "I had an experience a few weeks ago, which I should be quite reluctant to repeat under the same circumstances, if it could be avoided as well as not. I called to make an inspection at a stone works here, where they have two boilers, but use only one at a time. The engineer was working at his two pumps, which he could not get to throw water, and was scolding because he had no steam to run with, although he had had plenty only a short time before. The tubes in the boiler I was going to inspect were badly choked, and in fact nearly filled with soot from the coal. I thought that might be the trouble with the boiler they were using, so I opened the front of that boiler and looked into the tubes. *They were red hot.* I looked for the water. It was gone. I looked under the boiler to see the fire, and *jets of burning gas* were actually spurting out between the rivets on the seams over the fire. And the engineer was still working at his pumps, trying to get some water. I had a queer feeling just at that instant. I got the engineer away from the pumps as soon as possible and had him draw the fire; and I could see the gas burning along the seam while the fire was being drawn. As soon as it was darkened in the arch a little, I could see that the sheet on the bottom of the boiler was red hot for a space about three feet square. As soon as the boiler cooled down we opened the manhole, and found the inside to be bone dry. The outcome was that the seam next to the bridge-wall was badly fire-cracked and sprung, so that a new sheet had to be put in. The tubes all had to come out, and all the seams on the fire surface had to be re-calked; which I consider to be a very fortunate escape."

We have no comment to make upon this report, at present, beyond the statement that the inspector in question is a thoroughly honest and competent man.

We have received from Mr. C. J. H. Woodbury a copy of the *Annual Report* of the School Committee of the City of Lynn, Mass., for the year ending Dec. 31, 1893. It contains much interesting matter, and is a very creditable report. Among other things, we note with pleasure, on page 20, the following reference to the insurance of the boilers of the Lynn public schools in the Hartford Steam Boiler Inspection and Insurance Company: "The insurance of heating boilers in schoolhouses has been an advantage through the efficient service of their corps of inspectors, who have discovered need of repairs in several instances. These experts have also given to the janitors much information upon the best methods of caring for such boilers, and upon economy in fuel. Some changes have been made in the duties of certain janitors in schoolhouses heated by boilers, by relieving them of the care of other schoolhouses, so that they will not leave the boilers during school sessions. The Governor of Massachusetts appointed Mr. Thomas Hawley, a well-known steam engineering expert, to examine into the care and conditions of boilers in schoolhouses and public buildings, and it is a matter of satisfaction that the following portion of the report contained such a commendatory notice of the janitors and boilers in Lynn schoolhouses: 'The method of caring for the boilers of the schoolhouses in the city of Lynn is a good one. The boilers are all insured in the Hartford Steam Boiler Inspection and Insurance Company, and have the benefit of their regular and efficient inspection. Formerly the practice was to put a janitor in charge of several schoolhouses. The great danger of this practice I have reported to you before, and the proper authorities in Lynn have also realized this danger and some time ago guarded against it, so that now there is no excuse for a janitor to leave his boiler-room while the school is in session, excepting such as the Cobbett School, where two buildings are in the same yard, not a hundred feet apart. It would be possible, of course, for this janitor to spend too much time in one building and not enough in the other if he was so disposed, and such a condition might arise with a negligent janitor in disagreeable weather. The necessity of frequent observation of boilers of the sectional type, such as are used in these buildings, is quite important because of the small amount of water they contain. The general run of janitors in Lynn is above the average in intelligence, and the appearance of the boiler-rooms much more satisfactory. The city has an excellent engineer at the High School. This man was selected by competitive examination, and it is a matter of much importance that from over thirty applicants for the position less than five were at all worthy of consideration because of fitness, showing at once how large a number of men will apply for a position of responsibility, to fill which they have no qualification whatever.' "

The Dangers of the Trolley System.

In a recent issue of the *Standard* we find the following suggestive article by Mr. H. C. Cushing, Jr., on "Unknown Causes of Fires":

When electricity is allowed to roam at large and in vast quantities all along our water and gas pipes and through the ground upon which the city is built, in order to get back to the sources from which it was generated, which are the street railway power stations, it is this state of affairs which is creating a trouble the extent and seriousness of which are only known to those few who have made it a study. These street railway power stations, operating the overhead trolley system, are constantly generating thousands of horse-power of electricity, sending it out by overhead trolley and feed wires to the cars which it operates, and return it to the station by means of the water and gas pipes which lie in its course. For this reason there is a tremendous electrolytic action going on all the time. When I speak of this trouble from electrolysis I do not mean that Boston and Cambridge are the only cities affected, but every city in the United States operating a trolley system with ground returns. The writer has samples of gas and water pipe completely eaten through by electrolytic action in three months after having been placed in the ground near street railway returns. This effect has been going on and will continue to go on as long as there is a grounded wire in electric street railway construction.

Whenever this returning current flows in any quantity along a pipe there is bound to be a large fall of potential, varying in different pipes as their carrying capacity increases or diminishes.

In the cellars and basements of many houses I have found quite a large difference of electrical pressure between two pipes entering within one foot of each other, and in one instance it was a very easy matter to take a piece of hoop iron and draw an electric arc sufficient to ignite a piece of waste held near it, and by connecting these pipes together with a piece of No. 18 copper wire, the current flowing through it was sufficient to heat it so that it was impossible to lay one's hand upon it. In the basement of another building, not 200 yards from where the writer sits, I find a man using twenty-five amperes at eight volts pressure, or electricity enough to run small motors and incandescent lamps, as well as all the electrical bells in the entire building, by simply twisting his wires around two different water pipes which enter the building.

Some time ago my attention was called to two pipes which were so close together that the vibration of an elevator engine caused them to knock together just sufficient to create an arc every time a contact was made and broken. This had been going on so long that it had almost completely eaten through the gas pipe, and it is perfectly evident what would have taken place had this been allowed to go on unobserved. The gas would have been ignited, as soon as the first small hole appeared, by the electric spark, and disastrous results would have undoubtedly followed. This difference of electrical pressure upon water and gas pipes is now so well known that in a number of cases in the cities of Boston and Cambridge, the ordinary electric bell battery is entirely discarded and the wires from the bells connected directly to the water pipes, the latter furnishing an inexhaustible supply of electricity at the proper pressure to run any number of bells or gas-lighting apparatus, and also to do any quantity of mischief. I can see no reason why fires should not be attributed to this cause, when it can be proved that such a difference of electrical pressure really does exist between any two pipes entering a building in the vicinity of the trolley system of street railways.

There is only one way of eliminating this rapidly increasing danger, and that is by compelling the electric street railway companies to insulate, from the ground, their entire electric circuit, and just as soon as a suit for damages is brought by the water and gas companies for a complete system of pipes destroyed by electrolysis, the railway companies will begin to remedy the evil, which they are more fully aware of than any one else.

The Progress of the Telephone.

In a recent issue of the *Scientific American* we find an interesting address upon this subject, which was delivered by ex-Governor Long before the Committee on Mercantile Affairs of the Massachusetts legislature, when the American Bell Telephone Company asked the privilege of increasing its capital from $20,000,000 to $50,000,000. This company was incorporated in 1880, with a capital of $10,000,000; and in 1889 the legislature allowed it to increase its capital to $20,000,000, at which figure it now stands. Up to the first day of January, 1885, the company had expended $31,000,000 for materials and for labor. Since that date it has expended $12,349,000 in overhead equipment, over $10,000,000 for subways or underground conduits, and over $4,000,000 for cables. It has erected a million-dollar fire-proof building in Boston and other buildings in New York and other cities. In the one item of real estate it has expended $5,884,400 since January 1, 1885. Mr. Long stated, in speaking of the long distance systems, that the line from New York to Chicago is 1,200 miles long, or 2,400 miles for the complete "metallic circuit." This wire is of copper, one-sixth of an inch in diameter, weighing 435 pounds to the mile; and the total weight of the copper in the circuit is 1,044,000 pounds. In this and other long distance lines the company has expended $10,000,000. "Stand in New York city," said Mr. Long, "and you can talk with a man in Boston to the east, in Chicago or Milwaukee to the west, in Buffalo to the north, in Washington to the south. In other words, you are covering by the sound of your voice an area which contains half the people of the United States." At the beginning of

1881, the year after the first charter was granted, the number of miles of wire in use for telephonic purposes was 29,714; on January 1, 1894, it was 488,521, or twenty times the circumference of the earth. The putting of wires underground was begun about 1885. On January 1st of that year there were 1,225 miles of wire underground; and on January 1, 1894, there were 115,000 miles of it there. On the first day of the present year there were 566,491 telephones in use. In 1881, there were 47,800 subscribers; to-day there are 237,000. In 1884 there were 215,000,000 "talks" over the telephone; in 1893 there were 600,000,000. (The average number of *telegraphic* messages per year was stated by Mr. Long to be about 63,000,000.) The average expense to a subscriber for a single message is said to have been somewhere between 2 and 11 cents. The company employs over 10,000 persons. The largest switchboard is the one in New York city, which is 264 feet long, and represents 10,000 subscribers. The stock of the company consists of 200,000 shares. There are 5,277 stockholders, and of these stockholders, 3,721 (or nearly three-quarters of them) have holding of less than 25 shares each. The company pays into the treasury of the State of Massachusetts, annually, $150,000 in taxes.

These figures give a very good idea of the magnitude of the telephone interest in this country.

They Formed a Short Circuit.

The biggest snake story this spring was brought in to-day by Uriah Belden, who lives over in Devil's Hop Yard, near East Lyme, Conn. He says that a few days ago, while on a hunting tour in a patch of woods near Comstock's Bridge, north of here, he came upon a wheelbarrow load of large black snakes tied up in hard knots and stone dead. In the brush about the place he discovered twenty-five or thirty smaller black snakes, none of which was over eighteen inches long, many of which he killed. A couple of telegraph wires ran through the woods overhead, and Belden, who was much mystified by the tragedy of the snakes, soon after met a lineman, who gave him an interesting theory as to the probable solution of the deaths of the older serpents. There had been a heavy blast set off in a quarry near by a few days before, the lineman said, which broke down the telegraph wires and started a colony of black snakes from their winter slumber in a neighboring ledge. One of the wires, it appears, was "crossed" in a distant city by a deadly trolley wire, and hence the broken wires as they lay in a cart path near the snake's den, the ends not more than two feet apart, constituted a death trap. Any moist, living object touching the end of both wires at the same time would "short circuit" them, carrying the electric current from the "crossed" wire to the other, and incidentally sustaining a shock fatal to life. The lineman calculated that the snakes started up the cart path toward a brook after being disturbed by the blast and, as they came to the wires trailing on the ground, one after another crossed over and "short circuited" them, sustaining an instantaneous shock which caused death at once. Had it been possible for a snake's body to have still connected the wires after death, the lives of many of the snakes might have been spared, but immediately upon being shocked the snake curled up in a hard knot, thus opening the circuit and setting the trap again. The reason why the smaller snakes were not killed by the current was because their bodies were not quite long enough to reach from one wire to the other and complete the deadly "short circuit." Mr. Belden says he regards the lineman's idea as the correct one. He counted eleven of the snakes which were killed by the lightning. They were from three to eight feet long.—*New York Sun.*

The Engineer's Concert.

"I was loitering around the streets last night," said Jim Nelson, one of the old locomotive engineers running into New Orleans. "As I had nothing to do, I dropped into a concert and heard a sleek-looking Frenchman play a piano in a way that made me feel all over in spots. As soon as he sat down on the stool I knew by the way he handled himself that he understood the machine he was running. He tapped the keys way up one end, just as if they were gauges, and he wanted to see if he had water enough. Then he looked up as if he wanted to know how much steam he was carrying, and the next moment he pulled open the throttle and sailed on to the main line as if he was half an hour late. You could hear her thunder over culverts and bridges, and getting faster and faster, until the fellow rocked about in his seat like a cradle. Somehow I thought it was old '36' pulling a passenger train, and getting out of the way of a 'special.' The fellow worked the keys on the middle division like lightning, and then he flew along the north end of the line until the drivers went around like a buzz saw, and I got excited. About the time I was fixing to tell him to cut her off a little he kicked the dampers under the machine wide open, pulled the throttle way back in the tender, and how he did run! I couldn't stand it any longer and yelled to him that he was pounding on the left side, and if he wasn't careful he'd drop his ashpan. But he didn't hear. No one heard me. Everything was flying and whizzing. Telegraph poles on the side of the track looked like a row of cornstalks, the trees appeared to be a mud bank, and all the time the exhaust of the old machine sounded like the hum of a bumblebee. I tried to yell out, but my tongue wouldn't move. He went around curves like a bullet, slipped an eccentric, blew out his soft plug, went down grades fifty feet to the mile, and not a controlling brake set. She went by the meeting point at a mile and a half a minute, and calling for more steam. My hair stood up straight, because I knew the game was up. Sure enough, dead ahead of us was the headlight of a 'special.' In a daze I heard the crash as they struck, and I saw cars shivered into atoms, people smashed and mangled and bleeding and gasping for water. I heard another crash as the French professor struck the deep keys away down on the lower end of the southern division, and then I came to my senses. There he was at a dead standstill, with the door of the fire box of the machine open, wiping the perspiration off his face and bowing to the people before him. If I live to be 1,000 years old I'll never forget the ride that Frenchman gave me on a piano.—*N. O. Times-Democrat.*

A CORRESPONDENT criticises a statement recently made in this paper, to the effect that in tables of the properties of steam it is often assumed that the pressure of the atmosphere is an even 15 pounds per square inch. We are pleased to be criticised in a friendly spirit; but this fellow, having discovered a mole-hill which he fondly imagines to be a mountain, waxes insolent, and accuses us of divers things that he ought to know are not so. The focus of his letter seems to be the grandiloquent challenge to us, to produce one single, solitary instance of such a table as we referred to. We should be sorry not to satisfy him to this small extent, especially as we judge from his letter that his reading in steam engineering has not been very extensive. We refer him, therefore, to Edwards's *American Steam Engineer*, to Barr's *Steam Boilers*, and to Nystrom's *Steam Engineering*. We could refer him to others if it were worth while. (Nystrom, in the first two lines of his table, distinguishes between 14.7 and 15.0 lbs., but in the rest of the table he makes no such distinction.)

The Locomotive.

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NEW SERIES — VOL. XV. HARTFORD, CONN., MAY, 1894. No. 5.

The Chilling Action of Feed Water.

We have repeatedly called attention to the importance of locating feed-pipes correctly, and to the strains that are produced in boilers by the discharge of feed water in places where it will chill the shell. The contraction of iron from such a cause is practically irresistible, and the result is that joints are strained and boilers are badly damaged, simply because the importance of having the feed-pipe properly located is not understood.

A short time ago an excellent illustration of feed-pipe troubles came under our

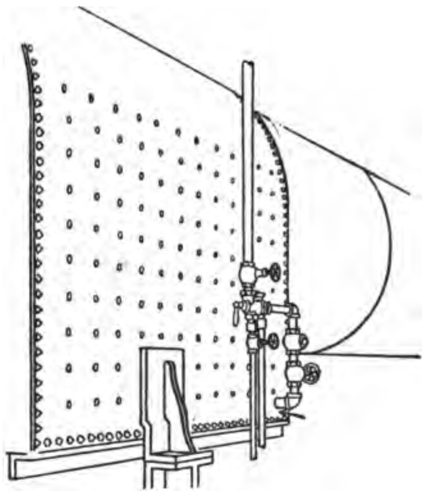

FIG. 1.— SHOWING THE LOCATION OF THE FEED PIPE.

observation, and, thinking the matter might interest readers of THE LOCOMOTIVE, we made some experiments with this boiler, both before and after changing the feed-pipe. The boiler in question is of the locomotive type, 24′ 3″ long, and with a 66-inch barrel. It is made of steel throughout, the plates being $\frac{3}{8}$″ thick, and the heads $\frac{7}{16}$″ thick. There are 114 tubes, 16 feet long and three inches in diameter ; and on the barrel there is a 30-inch dome, 36 inches high. The longitudinal joints are double-riveted, with $\frac{3}{4}$-inch rivets, and a pitch of $3\frac{1}{4}$ inches. The furnace is 72″ long, 66″ wide, and 60″ high. The stay-bolts, $\frac{7}{8}$″ in diameter, are pitched $5\frac{1}{2}$″ from center to center. The boiler has been in position only a short time, and has not yet been covered. It is supported, at the back end, on a cast-iron chair.

When the boiler was put in use, it was found that the girth joint, near the middle of the barrel, sometimes leaked. It was thought, by the engineer in charge, that this might be due to distress from the weight of the boiler and contents, and to relieve this distress he put another cast-iron chair under the middle of the barrel, near the troublesome girth joint. It was thought that this chair would sustain its share of the boiler's weight, and that the trouble would disappear. Such was not the case. The boiler behaved as badly as ever; and it was observed that when the joint leaked, the boiler was elevated at the middle of its length — "hogged up," as the saying is, — so that it did not rest on the middle saddle. At this point we were called upon to diagnose the case and suggest a course of treatment. The results of the diagnosis, and the success attending the application of the remedy we proposed, are given below, in the present article.

Having had a considerable experience with cases of this kind, we were at once led to

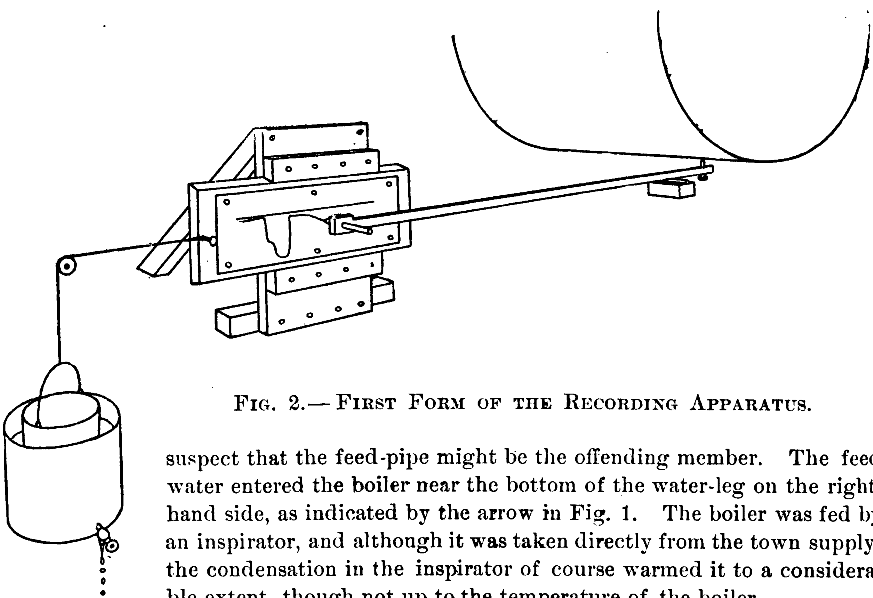

FIG. 2.— FIRST FORM OF THE RECORDING APPARATUS.

suspect that the feed-pipe might be the offending member. The feed water entered the boiler near the bottom of the water-leg on the right-hand side, as indicated by the arrow in Fig. 1. The boiler was fed by an inspirator, and although it was taken directly from the town supply, the condensation in the inspirator of course warmed it to a considerable extent, though not up to the temperature of the boiler.

Before proceeding to a description of the experiments, it will be well to state what we believed the cause of the trouble to be. The boiler was used for pumping water out of a quarry, and it frequently lay idle for a considerable time, with steam on, and ready for work at a moment's notice. When the boiler was doing no work, the damper being shut, and the fire-doors open, the circulation would naturally slacken, and after a while the water would become practically quiescent. Then if the inspirator were started, the comparatively cool feed water, heavier than that in the boiler on account of its lower temperature, would perhaps first displace the water in the lower part of the water-leg, and would then flow back along the bottom of the barrel of the boiler, chilling it and causing it to contract both longitudinally and girthwise. The contraction so produced would cause the bottom of the boiler to raise up, and this would lift it free of the middle saddle, at the same time straining the girth joint so as to make it leak. If the pump in the quarry were *running* at the time of feeding, there would probably be a good circulation in the boiler, and the cooler feed water would immediately mix with the circulation currents, and we should expect to find the leakage much smaller in amount than before, or perhaps not noticeable at all.

To test this theory (which our general experience had long indicated to be correct), we devised the apparatus shown in Fig. 2. It consists of a board with beveled edges, arranged so as to slide freely between guides screwed to an upright back-board. To the sliding board a piece of drawing paper was secured, against which rested a pencil attached to a lever in the manner shown. The other end of the lever was in contact with the bottom of the boiler, near the point at which the girth-joint passed under it; and the knife-edge fulcrum was so placed that the movements of the boiler were magnified by the lever eight times, — an elevation of the boiler-shell of ⅛ of an inch, causing the pencil to move precisely one inch. To draw the movable board along at a uniform rate, a pail containing sand was floated in a large bucket of water, and the water was allowed to flow slowly out of the bucket by means of a pet-cock. As the water level went down, the pail containing the sand followed it, and the board was drawn along so that the pencil drew an irregular line, representing the motion of the boiler.

It is difficult to adjust a small water-jet so that it shall have a uniform discharge, and for this reason the working of the apparatus was not so good as could be desired. However, the diagram shown in Fig. 3 was obtained by means of it, the times being

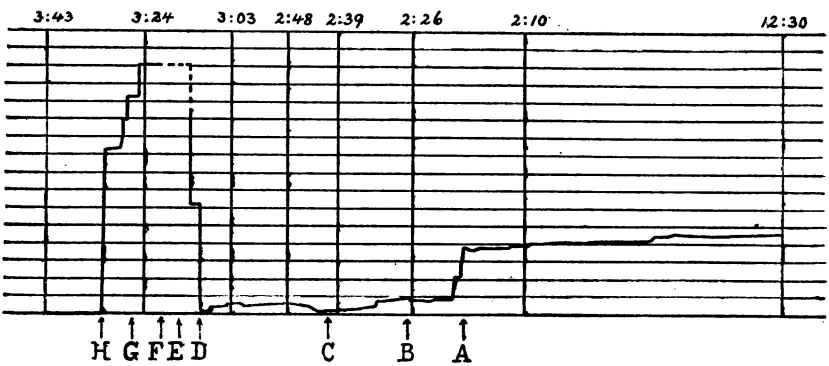

FIG. 3.— FIRST DIAGRAM OF THE MOVEMENTS OF THE BOILER.

recorded by marking the position of the pencil at frequent intervals. The lowest of the horizontal lines in Fig. 3 is the line drawn by the pencil by moving the board by hand, at a time when the boiler was down on the middle saddle (and therefore at its lowest point). The spaces between the equidistant horizonal lines each represent a motion of the boiler of one-fiftieth of an inch. The test was begun at 12:30 P. M., at which time, it will be seen, the boiler was 4½-fiftieths of an inch (or .09″) above its normal horizontal position. The quarry pump was not running, and the boiler was lying idle and doing no work whatever. Nothing was done for nearly two hours, during which time, it will be seen, the boiler scarcely moved. At 2:20 (marked *A* in the diagram) the quarry pump was started, and of course the water in the boiler was thereby put in circulation. This caused an equalization of temperature all over the shell, and it will be seen that the boiler came down immediately, until it was within a fiftieth of an inch of the normal position. With the quarry pump still running, and the circulation brisk, the inspirator was started at 2:27 (see *B*). As anticipated, there was no observable effect, and the inspirator was stopped again at 2:41 (see *C*). All this time the quarry pump was running, and it continued to run until 3:04. During all this time there had been no sign of leakage from the girth-joint, except the slightest trace of vapor, which had been occasionally visible between 12:30 and 2:20, when the air in the boiler-room was still. At 3:04 the quarry pump was stopped, and after waiting just one minute for the circulation to subside a little, the inspirator was started (see *D*). The boiler promptly rose until it was at least .28″ above the normal position. (The pencil, unfortunately, ceased to mark for a short time, and the dotted part of the record is conjectural.) The girth-joint plainly showed distress, and at 3:13 (see *E*) it was leaking water quite freely. At 3:19 (see *F*) the inspirator was shut off, but still the leak continued, and the boiler maintained its abnormal position. At about 3:27 (see *G*) the quarry pump was started again, and the resulting circulation speedily equalized the temperature in the boiler so that at 3:33 (see *H*) the boiler was resting on the middle saddle, and the leakage had entirely disappeared. The quarry pump continued running, and at 3:43, when the test was discontinued, the boiler was still in its normal position.

It was thought that the diagram we have described would suffice to demonstrate that the chilling action of the feed-water was responsible for the trouble that the owners of this boiler experienced, but as it was found impracticable to regulate the flow of water from the bucket satisfactorily, the apparatus was modified to some extent, and the experiments were repeated. The modification consisted in the substitution of a clock for the water bucket, as shown in Fig. 4. The face and hands of the clock were removed, and a carefully-turned hardwood pulley, 1¾″ in diameter, was secured to the hour spindle. The cord from the movable board was passed completely around this pulley, and to the end of the cord a weight was attached, which was found by experiment to be almost sufficient to overcome the friction of the board.

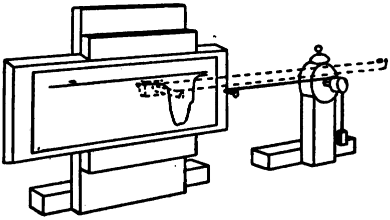

FIG. 4.—IMPROVED FORM OF THE RECORDING APPARATUS.

With the modified apparatus a new test was made, substantially as before. Marks were made on the moving board, at known intervals of time, for the purpose of testing the regularity of its motion, and it was found that in the improved form of the apparatus the motion of the board could be considered, without sensible error, to be absolutely uniform. The test was begun at 10:22½ A. M., at which time the quarry pump was running. At 10:23 the inspirator was started, with the pump still running, and for nine minutes there was no noticeable effect. The water level was purposely carried very high, and at 10:32 the boiler began to rise from the saddle, the circulation apparently being insufficient to take care of the large body of feed that was introduced. The inspirator was stopped at 10:34, but the boiler continued to rise until about 10:36. The girth seam began to leak water about 10:32, and at 10:38, four minutes after the inspirator was stopped, the circulation seemed to succeed in equalizing the temperature again, for the boiler went down promptly until it rested on the saddle, and the leak disappeared. From this time until 10:57 the boiler did not leave the saddle by more than the hundredth part of an inch. At 10:57 the quarry pump, which had been running ever since the experiment began, was stopped, and the boiler began to rise very slowly, and it was a trifle more than .04″ above the saddle at 11:28. It is not easy to say what was the cause of this slight variation, but as the boiler was uncovered, and the cool, out-door air blew against the bottom of it through a window, it is possible that the chill so produced was sufficient to cause the observed rise. At 11:28 the inspirator was started, and the boiler, reversing the usual proceedings, immediately went *down* about .02". After the inspirator had been running about six minutes the boiler suddenly began to rise again, and the girth joint began to leak steam. At 11:39, with the inspirator still running, the quarry pump was started, and the increased circulation brought the boiler down on the saddle with great promptness. The inspirator was stopped at 11:43, and the experiment was brought to an end at 11:50.

After the experiments described above were completed, the feed-pipe was re-arranged. The opening through which it entered the water-leg (see Fig. 1) was plugged up, and the feed was led to the top of the barrel of the boiler and was passed downward

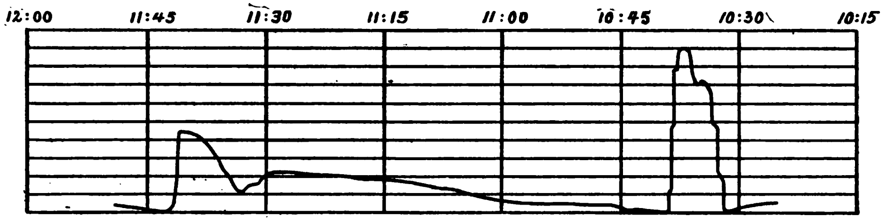

FIG. 5.— SECOND DIAGRAM OF THE MOVEMENTS OF THE BOILER.

through the shell at a point on the furnace side of the dome. After passing down nearly to the level of the tubes, the feed-pipe was run horizontally along the tubes for a distance of 13 feet, which brought it within three feet of the back head. At this point a tee was secured to it, and branch pipes to the right and left were screwed into the tee, so that the discharge would take place at the sides of the barrel. It was believed that the feed water, running through this considerable length of internal pipe, would be heated nearly to the temperature of the boiler before it was discharged, so that its chilling action would no longer be appreciable; and subsequent experiment showed this to be the case. (We always recommend the use of an internal feed-pipe. Those inter-

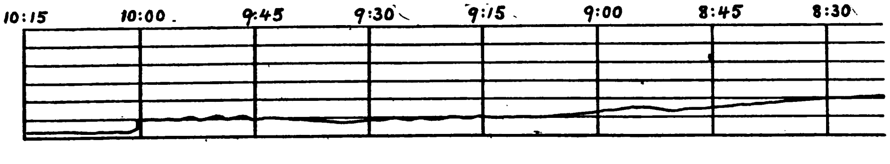

FIG. 6.— THIRD DIAGRAM, TAKEN AFTER CHANGING THE FEED PIPE.

ested in the arrangement recommended for the ordinary horizontal tubular boiler will find it described in the issues of THE LOCOMOTIVE for May, 1883, and January, 1893.)

After the feed-pipe had been changed, another diagram was taken from the boiler, with the result shown in Fig. 6. (The diagrams are all on the same vertical scale, and in each case the space between any two adjacent parallel horizontal lines represents a motion of the boiler of $\frac{1}{50}$th of an inch.) The experiment was begun at 8:21 A. M., with the quarry pump running slowly. There was no leak visible, and the boiler was within about .04" of the saddle. With the pump still running slowly, the inspirator was started at 8:50. At 8:58 the pump was set at work at full speed, and the inspirator was stopped again at 9:11. At 9:32 the quarry pump was stopped also, and after allowing nine minutes for the circulation to subside, the inspirator was started once more (with the boiler idle) at 9:41. The inspirator was stopped at 10:00, and at 10:01 the quarry pump was started. The experiment came to an end at 10:14, as it was considered that the efficacy of the remedy we had proposed was abundantly proved. Instead of the violent changes observed in the earlier diagrams we had obtained a fairly uniform line, and the entire range of the motion of the boiler was less than .04". No leakage was observed, and neither the inspirator nor the quarry pump had the least observable effect on the boiler, except for the slight fall towards the normal position observed when the pump was started at 10:01; and even then the motion amounted to only about .01".

Throughout these experiments records were kept of the steam pressure, of the times of firing, and of the position of the damper. There was evidently no connection whatever between any of these things and the motion of the boiler, so they have not been enumerated in the present article. The pop-valve on the boiler was set at 100 lbs., and during the course of the experiments it blew off once. This was at 9:15, on the third day (Fig. 6). It blew for only about thirty seconds, and evidently did not disturb either the boiler or the apparatus.

The effect of cold feed water on shell-plates and girth joints is discussed, in accordance with theoretical principles, in THE LOCOMOTIVE for March, 1893.

Inspectors' Report.

MARCH, 1894.

During this month our inspectors made 7,915 inspection trips, visited 16,700 boilers, inspected 6,512 both internally and externally, and subjected 527 to hydrostatic pressure. The whole number of defects reported reached 11,324, of which 1,181 were considered dangerous; 63 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	914	64
Cases of incrustation and scale,	1,965	78
Cases of internal grooving,	93	15
Cases of internal corrosion,	522	36
Cases of external corrosion,	789	56
Broken and loose braces and stays,	187	53
Settings defective,	350	42
Furnaces out of shape,	428	29
Fractured plates,	317	57
Burned plates,	324	26
Blistered plates,	295	16
Cases of defective riveting,	1,188	14
Defective heads,	92	22
Serious leakage around tube ends,	2,045	407
Serious leakage at seams,	489	31
Defective water-gauges,	294	54
Defective blow-offs,	201	38
Cases of deficiency of water,	14	10
Safety-valves overloaded,	72	31
Safety-valves defective in construction,	90	24
Pressure gauges defective,	527	42
Boilers without pressure gauges,	29	29
Unclassified defects,	99	7

Boiler Explosions.

MARCH, 1894.

(58.) — A boiler exploded, on March 1st, at Freely's Mills, in Elroy township, near Warsaw, Ind. Engineer Frank Ripley was blown seventy yards away, and instantly killed. Superintendent Charles Dawson was pinned down by falling timbers, and before he could be rescued he was scalded to death. Fireman William Webb was also fatally scalded. John Freely, one of the proprietors, was struck by a flying fragment of the boiler. Both of his legs were broken, and he will die. Several other men were badly scalded and otherwise injured. Two buildings were wrecked, and a fire which followed the explosion did much damage.

(59.) — Two men were killed, and another was severely injured, by the explosion of a boiler at Gulf, Chatham county, N. C., on March 1st. The mill in which the boiler stood was completely wrecked, and parts of the boiler were found 300 yards away.

(60.) — A large boiler in Renshaw's livery stable, at Plymouth, near Wilkesbarre, Pa., exploded on March 3d. The dome of the boiler blew off, and went up through the building, to the roof. It passed within two feet of a bed on which Marvin Renshaw, a son of the proprietor, was sleeping. The bed was blown against the ceiling, and Mr. Renshaw received slight injuries. John Morgan, who was in the boiler room at the time of the explosion, was seriously scalded. The building was set afire, but the flames were soon controlled.

(61.) — A boiler exploded, on March 6th, in Hammond Bros.' mill, at Rock Elm, near Ellsworth, Wis. Considerable damage was done to the property. Otis Lehman's leg was broken, and Joseph Weix and Charles McKernon were badly scalded. It is said that the fire-box of the boiler was defective.

(62.) — A boiler exploded in the McDonald oil fields on March 6th. It was located at the Forest Oil Company's No. 4 Dixon well, back of Willow Grove, near Pittsburgh, Pa. Edward Neely, who was in the boiler shed at the time, was blown high in the air, and instantly killed.

(63.) — A boiler belonging to Mr. T. M. Douglass, of Plain City, Ohio, exploded on March 7th. Mr. Douglass, who was his own engineer, was badly scalded.

(64.) — On March 7th a boiler belonging to Mr. George Kelly exploded at Ridgeway, Ill. Engineer Charles Caldwell and five other men were badly injured, and some of them will probably die.

(65.) — The boiler of locomotive No. 468, of the Lehigh Valley railroad, exploded on March 8th, at Tannery Siding, near White Haven, Pa. John Lenox, Arthur Dotter, and Edward Fox, who were on the locomotive at the time, were instantly killed, and engineer Patrick Dugan, who was in the telegraph office, was knocked down and bruised. The locomotive was completely wrecked, and the track and embankment were badly torn up.

(66.) — An upright boiler in the machine shop of Fahey & Fowler, Pittsburgh, Pa., exploded on March 9th, killing Otto Kelleher and seriously injuring Frank Fowler. Mr. Fowler received an ugly scalp wound, a compound fracture of the lower jaw, and severe burns about the arms and legs. It is known that Fowler was hauling the fire at the time of the explosion.

(67.) — On March 14th a boiler exploded at Vale's mill, in Sombra Township, near Dresden, Ont. The mill had just shut down for the noon hour. Engineer Adam Cornell and his three children, who were in the boiler room, were killed. The building was entirely demolished. Mr. Cornell's children had just brought him his dinner. The two little girls were hurled in opposite directions, and were found 100 yards from the scene of the explosion. The boiler passed directly over a neighboring house.

(68.) — On March 13th, while Mr. James A. Frazier and Mr. A. E. White were on the little locomotive that runs from Goshen, Va., to the Victoria mines, the boiler of the locomotive burst. The engineer was seriously scalded, and Mr. Frazier's face and hands were badly cut. Mr. White escaped without injury.

(69.) — A boiler used in drilling oil wells on the Warren-Barber farm, just east of Mendon, near Celina, Ohio, exploded on March 13th, with terrific force, but fortunately nobody was injured. The men were at work on the derrick, two hundred feet from the boiler. A large piece of the boiler was blown half a mile into the woods, where it cut down a tree.

(70.) — A boiler exploded at the Knowles, Taylor & Anderson sewer pipe works, in East Liverpool, Ohio, on March 15th. Engineer William Anderson, and William Gilkinson and George Anderson, were severely burned about the face and hands. The boiler room was almost demolished.

(71.) — Peter Guldenbronson, Charles Moore, Mary Evans, and Harriet Brown were injured in a boiler explosion at the Elite laundry on West Madison street, Chicago, on March 17th. Guldenbronson is a machinist, and was at work in the engine room. Over twenty men and women were at work in the laundry at the time. The boiler was shattered into a hundred pieces, one of which struck Guldenbronson, breaking his jaw and bruising him badly.

(72.) — On March 19th a boiler exploded in W. M. Bertley's mill, on East Second street, Los Angeles, Cal. The boiler was hurled through the roof of the mill, and landed about 100 feet away. Fortunately nobody was hurt.

(73.) — A boiler at the Syracuse coal shaft, near Pomeroy, Ohio, exploded on March 20th, badly burning the engineer, G. W. Nease.

(74.) — A boiler in the machine shop of Swanson Bros. & Meeter, at Hawarden, Iowa, exploded on March 23d, and two men, Levi Gleason and Frank Swanson, were badly scalded and bruised by the flying débris. The boiler went through the west side of the shop and crashed into J. T. Van Orman's stable, making a complete wreck of the office. Gleason's legs were badly scalded and his face was burned and bruised. Swanson was not quite so badly injured, though his left side was severely burned.

(75.) — On March 24th a boiler exploded in the Haeger brick and tile factory, at Gilberts, near Elgin, Ill. The entire plant was demolished, and the fire that ensued nearly destroyed the town. August Tarnow, a fireman, was in the boiler room when the explosion occurred. He was killed, and his body was buried in the débris. Adjoining the exploded boiler was another one of similar size, which had not been used for some time. The explosion blew the idle boiler from its setting, and through a brick wall. It landed outside of the building. The total loss was estimated at $50,000.

(76.) — The pump-boat *Hero*, belonging to Armstrong Bros., of Point Pleasant, W. Va., burst her boiler on March 28th, killing the engineer, John McGuffin, and injuring several others. The United States Inspectors were on board the *Annie L.* (which was lying alongside the *Hero*) at the time, and one of them, Mr. Ira Huntington of Gallipolis, was quite severely scalded. They would all have been killed had they not been in the engine room of the *Annie L.* The *Hero* was totally wrecked, and sank in two minutes. One side of the *Annie L.* was also badly damaged. The body of engineer McGuffin could not be found.

(77.) — A boiler exploded on March 31st in A. W. Marshall's foundry, at Hickory, near Statesville, N. C. Mr. Marshall was cut in several places, and his engineer was scalded on the hands and legs.

The Causes of Fires.

The *Chronicle*, a weekly insurance paper published in New York city, has recently issued an extra number in which the causes of fires have been exhibited graphically for different classes of property. The classification is very complete, as it embraces no less than 129 heads, beginning with "Agricultural Implement Factories," and ending with "Worsted and Yarn Mills." The diagrams are based on statistics prepared for the *Chronicle Fire Tables*, and in making them up tens of thousands of fire reports have been examined in the more common risks, and in only a very few cases (in classes of risks in which fires are not frequent) has the number of fires examined been less than one hundred. In commenting on the diagrams and illustrating their usefulness, the *Chronicle* says: "In agricultural implement factories it is plain that the inspector should give his first attention to the dirt and rubbish where spontaneous ignitions may happen; he should be almost equally alert to discover to what extent the risk is protected against sparks. Almost one-half of the inherent hazard in asylums is in defects in flues. In bakeries and confectioneries, defective ovens, grease, flues, stoves, and matches are responsible for nearly two-thirds of the fires. In blacksmith shops, as one would expect, the greatest danger is from sparks. In brick and tile works, overheated and defective kilns, and sparks and engines, cause three-fourths of the fires. In breweries, sparks, dust explosions, friction in machinery, ignition of tar, and spontaneous combustion cause nearly fifty per cent. of the fires. In candy factories, chimneys, furnaces, stoves, and gas jets are the things to look after. In carriage and wagon factories, spontaneous combustion, sparks, defective flues, and stoves are the chief sources of danger. In clothing factories, stoves, matches, ashes, lamp explosions, and furnaces are more dangerous than a host of minor causes. In cotton goods factories, friction in machinery causes nearly two-thirds of the fires. Locomotive sparks cause most of the fires in cotton in transit. In dry goods stores, gas jets, lamps, and matches are the principal hazards. In dwellings, defective flues, matches, and lamp explosions cause one-half of all the fires. In electric light stations, electric wires, lightning, and engines and boilers cause more fires than all other sources combined. In grain elevators, locomotive sparks, friction in machinery, and spontaneous combustion are the underwriters' enemies. In greenhouses and floral establishments, furnaces and defective flues are far in the lead. In hotels, defective flues, stoves, and explosions of lamps are the chief fire causes. In livery stables, cigar stubs, lamp explosions, matches, and defective flues produce about as many fires as all other hazards combined. In schoolhouses, defective flues and the heating apparatus are the principal fire causes. In theaters, the devices for lighting cause one-third of all the fires. And so on, throughout the list."

These diagrams should be of exceeding value to insurance men, for they are very complete, and they tell their story at a glance.

The Locomotive.

HARTFORD, MAY 15, 1894.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

Subscription price 50 *cents per year when mailed from this office.*

Bound volumes one dollar each. (Any volume can be supplied.)

Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

WE have received the *Report* of the Badische Gesellschaft zur Ueberwachung von Dampfkesseln (of Mannheim), the *Report* of the Norddeutscher Verein zur Ueberwachung von Dampfkesseln (of Hamburg), the *Report* of the Märkischer Verein zur Prüfung und Ueberwachung von Dampfkesseln (of Frankfurt), and the *Report* of the Schlesischer Verein zur Ueberwachung von Dampfkesseln (of Breslau); and we desire to express our thanks for them to the respective associations.

WE desire to acknowledge a copy of *Notes on Steam Boilers*, by Professors C. H. Peabody and E. F. Miller. This book, as we understand it, is not published for general circulation, but for the use of the students in the Massachusetts Institute of Technology, in connection with their course in steam engineering. The volume has been carefully prepared, and should be quite useful. Readers of THE LOCOMOTIVE will be interested to know that the authors have drawn largely on the back numbers of this periodical for cuts and other matter.

THE famous Ferris Wheel is finally being taken apart, for shipment to New York. According to the *Chicago Tribune*, "It will take ten weeks to take the wheel to pieces. The car that was used for carrying the Krupp gun will be used for carrying the seventy-ton axle. The material will be taken in five trains of thirty cars each to New York city. There are 3,000 tons of metal in the wheel, and 500,000 feet of timber is needed for the false work. Taking the wheel down will be more dangerous than putting it up. Only one life was lost in erecting the big attraction. The expense of taking down, moving, and rebuilding the wheel will be $150,000. In New York it is to be placed at Thirty-seventh Street and Broadway. Old Vienna will be reproduced around it. Here the wheel had 3,000 electric lights; in New York the number will be doubled. The old Ferris Wheel Company goes out of existence, and a new company, composed of New York men, has been formed. Superintendent L. V. Rice has charge of the removal. During the fair the wheel went around 10,000 times, and carried 2,000,000 passengers. The largest single load was carried October 19th, when, at 12.30 o'clock, 1,768 people were in the cars. The largest day's business was October 10th, when 38,000 people were carried. October 9th, 10th, and 11th there were 114,000 passengers, the largest average for any three days."

THE *Pall Mall Gazette*, in an interview with one of the leading taxidermists of London, brings to light some curious facts about rare birds and their eggs. "Of course," said the great taxidermist, "you know I have made some dodos and a great auk. No? Evidently you are an amateur at taxidermy. My dear fellow, half the great auks in the world are not genuine. We make 'em of grebes' feathers and the like. And the great auk's eggs, too! We make the eggs out of fine porcelain. I tell you it is worth while. They fetch — well, one fetched £300 ($1,500) only the other day. That one was really genuine, I believe; but, of course, one is never certain. It is very fine work, and afterwards you have to get them dusty, for no one who owns one of these precious eggs has ever the temerity to clean the thing. That's the beauty of the business. Even if they suspect an egg, they do not like to examine it too closely. It is such brittle capital at the best. You did not know that taxidermy rose to such heights as that? It has risen higher. I have rivaled the hands of nature herself! One of the *genuine* great auks" — his voice fell to a whisper — "one of the *genuine* great auks *was made by me!* And, what is more, I have been approached by a syndicate of dealers to stock one of the unexplored skerries to the north of Iceland with specimens. I may — some day." — *Ex.*

The Average Speed of the "Campania" and "Lucania."

The Cunard steamer *Campania* has now completed a year's service, having started on her maiden voyage from Liverpool on April 22, and it will interest our readers to have official returns as to the performances during that period. By the kindness of the Cunard company we are enabled to give accurate details in the accompanying tables,* two of which give all the round voyages to date of the *Campania*, and the other two those of the *Lucania*. These tables scarcely require any comment, except, perhaps, to point out that on several voyages the vessels experienced heavy weather, the effect of which is reflected in the duration of the voyages and in the mean speed. We might have quoted from the logs regarding contrary winds, head seas, and a continuance of bad weather, and demonstrated that on some occasions the vessels were in this respect unlucky. The mean speed of all the passages, however, is really most satisfactory. The mean speeds for the round voyages out and home are summarized, separately, in the last of the tables given below.

WESTWARD VOYAGES OF THE "CAMPANIA"—1893-4.

No. of Voyage.	Left Roche's Point.	Arrived Sandy Hook.	Duration of Passage.			Total Distance.	Average Speed.
			d.	h.	m.	Knots.	Knots.
1	Apr. 23, 1:08 P.M.	Apr. 29, 5:24 P.M.	6	8	51	2,858	18.70
2	May 21, 2:45 "	May 27, 7:25 A.M.	5	21	15	2,812	19.92
3	June 18, 0:43 "	June 24, 0:30 "	5	16	22	2,880	21.11
4	July 23, 0:53 "	July 29, 11:42 P.M.	5	15	24	2,796	20.65
5	Aug. 20, 1:38 "	Aug. 26, noon.	6	2	57	2,781	18.93
6	Sept. 17, 1:23 "	Sept. 23, 3:10 A.M.	5	18	22	2,802	20.25
7	Oct. 15, 1:23 "	Oct. 20, 10:25 P.M.	5	13	37	2,783	20.83
8	Nov. 12, 0:50 "	Nov. 18, 5:00 A.M.	5	20	45	2,790	19.83
9	Mar. 11, 2:37 "	Mar. 18, 11:04 P.M.	6	13	02	2,863	18.24

[* These tables have been condensed from the original. ED. LOCOMOTIVE.]

EASTWARD VOYAGES OF THE "CAMPANIA"—1893-4.

No. of Voyage.	Left Sandy Hook.	Arrived Roche's Point.	Duration of Passage.			Total Distance.	Average Speed.
			d.	h.	m.	Knots.	Knots.
1	May 6, 11:40 A.M.	May 12, 9:47 A.M.	5	17	32	2,927	21.29
2	June 3, 10:42 "	June 9, 11:35 "	5	20	18	2,895	20.63
3	July 1, 8:47 "	July 7, 8:40 "	5	19	18	2,913	20.91
4	Aug. 5, 1:18 P.M.	Aug. 11, 0:50 P.M.	5	18	57	2,825	20.34
5	Sept. 2, 0:36 "	Sept. 8, 8:15 A.M.	5	15	04	2,816	20.84
6	Sept. 30, 10:37 A.M.	Oct. 6, 11:42 "	5	20	30	2,820	20.07
7	Oct. 28, 9:10 "	Nov. 3, 2:00 "	5	12	15	2,799	21.17
8	Nov. 25, 8:51 "	Dec. 1, 6:20 "	5	16	54	2,820	20.60
9	Mar. 24, 9:51 "	Mar. 30, 6:10 "	5	15	44	2,871	21.16

WESTWARD VOYAGES OF THE "LUCANIA"—1893-4.

No. of Voyage.	Left Roche's Point.	Arrived Sandy Hook.	Duration of Passage.			Total Distance.	Average Speed.
			d.	h.	m.	Knots.	Knots.
1	Sept. 3, 1:33 P.M.	Sept. 9, 0:45 A.M.	5	16	19	2,751	20.18
2	Oct. 1, 0:54 "	Oct. 6, 10:20 P.M.	5	14	01	2,782	20.76
3	Oct. 29, 0:40 "	Nov. 3, 9:07 "	5	13	02	2,780	20.90
4	Nov. 26, 1:20 "	Dec. 2, 0:37 A.M.	5	15	52	2,785	20.49
5	Feb. 25, 2:20 "	Mar. 4, 2:02 "	6	16	17	2,876	17.94
6	Mar. 25, 0:09 "	Mar. 31, 2:21 "	5	18	47	2,907	20.94

EASTWARD VOYAGES OF THE "LUCANIA"—1893-4.

No. of Voyage.	Left Sandy Hook.	Arrived Roche's Point.	Duration of Passage.			Total Distance.	Average Speed.
			d.	h.	m.	Knots.	Knots.
1	Sept. 16, 11:02 A.M.	Sept. 22, 9:53 A.M.	5	17	16	2,785	20.29
2	Oct. 14, 10:19 "	Oct. 20, 4:35 "	5	13	41	2,802	20.96
3	Nov. 11, 9:20 "	Nov. 18, 4:55 "	6	15	00	2,853	17.94
4	Dec. 9, 8:03 "	Dec. 15, 3:13 "	5	14	35	2,817	20.93
5	Mar. 10, 9:47 "	Mar. 16, 3:36 "	5	13	14	2,900	21.77
6	Apr. 7, 8:45 "	Apr. 13, 3:00 "	5	13	40	2,892	21.63

It will be seen that the mean speed of the *Campania* for the nine voyages of over 50,000 nautical miles has been 20.304 knots [23.38 miles], while the *Lucania* in her six voyages of over 33,500 miles has averaged 20.394 knots [23.48 miles]. The mean of all the outward [westward] voyages of the *Campania* was 19.83 knots, and on the homeward [eastward] voyages 20.779 knots. In the first run, which affects the mean considerably, caution was desirable, owing to the fact that the engines had not been for long under steam. In the case of the *Lucania* the mean of the six outward runs is 20.202 knots, and of the homeward runs 20.586 knots. It may be added that three years ago we gave detailed returns of performances by competitive liners, and that the highest mean over six or seven voyages was about 19.1 knots, so that on this comparison the *Campania* and *Lucania* are 1¼ nautical miles per hour ahead of any of the other vessels, including the *Majestic*, *Teutonic*, *New York*, and *Paris*.—*Engineering.*

MEAN SPEED ON ROUND VOYAGES.

Voyage.	*Campania.*	*Lucania.*
1	20.00 Knots.†	20.235 Knots.
2	20.275 "	20.86 "
3	21.01 "	19.42 "
4	20.495 "	20.71 "
5	19.885 "	19.855 "
6	20.16 "	21.285 "
7	21.00 "	. . .
8	20.215 "	. . .
9	19.70 "	. . .
Means,	20.304 Knots. [23.38 miles.]	20.394 Knots. [23.48 miles.]

[† A knot, according to the British Admiralty, is 6,080 feet.]

[NOTE. We are aware that there are several mistakes in these tables, but they are of such a character that we cannot correct them with the data at hand, so we reproduce the figures as given in *Engineering*. For example, in the ninth westward voyage of the *Campania* the duration of the passage is evidently over *seven* days (*i. e.* 7 d. 13 h. 02 m.), according to the given dates of departure and arrival. Undoubtedly one of these dates is in error by an even day. — ED. LOCOMOTIVE.]

IN the January issue of THE LOCOMOTIVE, in connection with the table of the properties of steam, it was inadvertently stated that the pressure as read by the gauge is *greater* than the equivalent absolute pressure as reckoned from a vacuum — the fact being, of course, that the *absolute* pressure is the greater of the two. Slips of this kind are unfortunate, but in the present case nobody could be misled. All the rest of the article showed plainly that the intention was to count the absolute pressure as the greater, and we have no doubt that all of our readers noticed the slip and passed it by charitably.

Parker's Uncomfortable Plight.

Henry Parker, colored, an employe of the Pictet Ice Company's factory, is the victim of an amusing as well as a distressing accident. For more than two hours he was held a prisoner in a large boiler, and it was only by the liberal use of axle grease and the loss of all his clothing that he was finally rescued. Parker went into the boiler immediately after dinner Thursday to clean it out. The flues inside the boiler are arranged so that at one end there is some spring to them. The other end, where they connect with the boiler, is more solid. Parker backed unconsciously between the flues until he reached the end of the boiler. When he attempted to come back, however, he found to his surprise that his body was tightly wedged between the flues. Struggle as he would Parker could not release himself. His calls brought several men to the scene. When Parker explained his situation the first impulse of his fellow workmen was to laugh. Two men went into the boiler to release him, but their combined efforts only brought shrieks of pain from the unfortunate. Some one telephoned to Dr. Mandeville Thum. A machinist was also sent for, and both arrived about the same time. All sorts of schemes were concocted by the physician, the machinist, and the now thoroughly frightened workmen. To cut through the boiler would take several hours, so that had to be given up as impracticable. With the most pitiful groans Parker insisted that the flue pipes were slowly closing in on him and squeezing out his breath. Dr. Thum hit upon a plan. He sent the machinist into the boiler with a knife. By tearing and cutting the machinist succeeded in removing most of Parker's clothing. A box of axle grease was then brought into use, and Parker's body was thoroughly greased where the pipes did not hold it. A rope was then tied just below his shoulders. All the men outside then caught the end of the rope and pulled. The hips appeared to be the principal place of resistance. A shriek came from Parker as the rope began to tighten, and then his body suddenly shot forward. All of his clothes were left behind and the man was pulled out of his prison as naked as the day he was born, his whole body glistening with grease. Parker's hips and one leg were a mass of bruises, and he had to be carried to his home in a neighboring alley. It will be two weeks before he is able to work again.—*Louisville Courier-Journal.*

A Boiler that Needed Repairs.

Once upon a time there was a man who had a knife. The blades of the knife, one by one, got so badly nicked and otherwise injured that new blades were substituted for them as occasion required. Finally the handle went to pieces, and a new one was provided. The question was then discussed at the grocery store whether this was the same old original knife or not. Some of the Solons of the village held that as it contained no portion of the original knife, it must be a different one. Others held that it was certainly the same knife, in spite of the repairs; and these men supported their claims by referring to several instances in which churches and other structures had been repaired in a similar manner, and pointing out that in cases in which the lease of the land on which they stood was to terminate with the life of the building, the courts had decided that the individuality of the building had not been destroyed by the repairing process. Whatever the merits of the case may have been, the story goes that the second of these arguments prevailed, and that it came to be universally admitted that the repaired knife was the same old knife, sure enough. But when this decision had been reached, the owner of the knife produced all the old blades and rivets and bits of handle, which he had saved up, and assembled them into a new knife. Then the question arose, if the repaired knife was the same knife as the original, then what knife was this patched-up affair that contained all the identical parts of the first one?

About this time, we imagine, the reader will be wondering what all this has to do with the heading of this article. Well, let him read what follows, and we fancy he will see the connection. "The Department of Workshops and Factories," says the *Columbus* (Ohio) *Dispatch*, "has received frequent complaints from citizens of Gahanna as to the condition of the boiler used at the Gahanna mill, owned by Frank E. Morgner. While the department does not claim to have jurisdiction over such matters, yet the complaints became so numerous that an inspection was made by Deputy Inspector J. H. Ellis, assisted by an expert boiler inspector. The flues and other parts of the boiler were found to be thoroughly demoralized, and several holes were punched in the boiler, as a test and at the same time to insure its repair before again being used. The inspector recommends as follows: 'Remove all the old flues and put in new ones, remove the sheets over the fire grates and replace them with new sheets, and where the boiler has become thin and rusted cut out such places and patch; repair the blow-off plug, provide a new front support and a new breeching and stack, and provide substantial hand railings on stairways.' The citizens paid for the services of the boiler inspector.'

Electric Railway Dangers.

In the April issue of THE LOCOMOTIVE we published an article on this subject by Mr. H. C. Cushing, Jr. The following item from the *Scientific American* will be of interest in connection with Mr. Cushing's article:

"At a recent meeting at Washington of the National Electric Light Association, Mr. J. H. Vail, M.I.C.E., of New York city, brought forward a number of interesting cases of electrolysis. Among them were the following. A plumber in a Pennsylvania city was repairing a water pipe in a house, and on breaking a joint, an electric arc formed across the ends of the pipe. The house was not in the direct path of the railway circuit. Investigation followed, and it was proved beyond question that there was insufficient conductivity in the track system, and also that the earth did not afford a good return, though the tracks were well grounded. It was found that the railways current was traveling along all pipe systems in its effort to complete the circuit to the dynamos in the power station. Actual tests were made with standard instruments. From 135 readings of the ampere meter, it was found that the water pipes leading into the station carried an average current of 93 amperes. Further tests showed that with 23 cars in operation, 40 per cent. of the total current was carried by underground pipes. Another interesting case was brought to light by a fire in the basement of a house. After it was extinguished, it was found that the current of an electric railway system had been carried along the water pipe entering the house. It is believed that, by vibration of the floors, this pipe and a gas pipe were brought repeatedly into contact — each time forming an arc between them. In this way a hole was eaten into the gas pipe and the gas was ignited. After an analysis of the whole matter, Mr. Vail felt justified in recommending the adoption of the complete metallic circuit as the standard for the best railway practice."

A STRANGE accident happened to Mrs. G. M. Williams at her home on Second street recently, which proved exceedingly painful. She had nearly finished her Monday's washing and had a boiler full of clothes over a hot fire in the kitchen. While in the act of pushing the clothes under the water with a stick, an explosion occurred in the bottom of the boiler and nearly a gallon of the boiling water, accompanied by a burst of steam, was thrown over Mrs. Williams' head and shoulders. She was severely scalded on the head, right side of her face, and across her shoulder and bosom. — *Santa Rosa Democrat.*

WE have received one account of an explosion of some kind, which we do not exactly understand. It was in an electric light plant, and the report says that "it was found that the vacuum in the receiver had been reduced and that a large amount of steam had leaked in, causing the thing to explode." It is a relief to hear that "the damage is not heavy, save to the building, which has large holes punched in the walls."

The Locomotive.

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NEW SERIES — VOL. XV. HARTFORD, CONN., JULY, 1894. No. 7.

A Boiler Explosion on a Tug Boat.

We present, herewith, some particulars of the boiler explosion on the steam tug *Rambler*, which occurred recently while the boat was tied up at Pocket Dock, New Haven, Conn. An hour previous to the explosion the *Rambler* had towed a four-masted schooner down the bay, and she had returned to the dock to meet some friends of Cap-

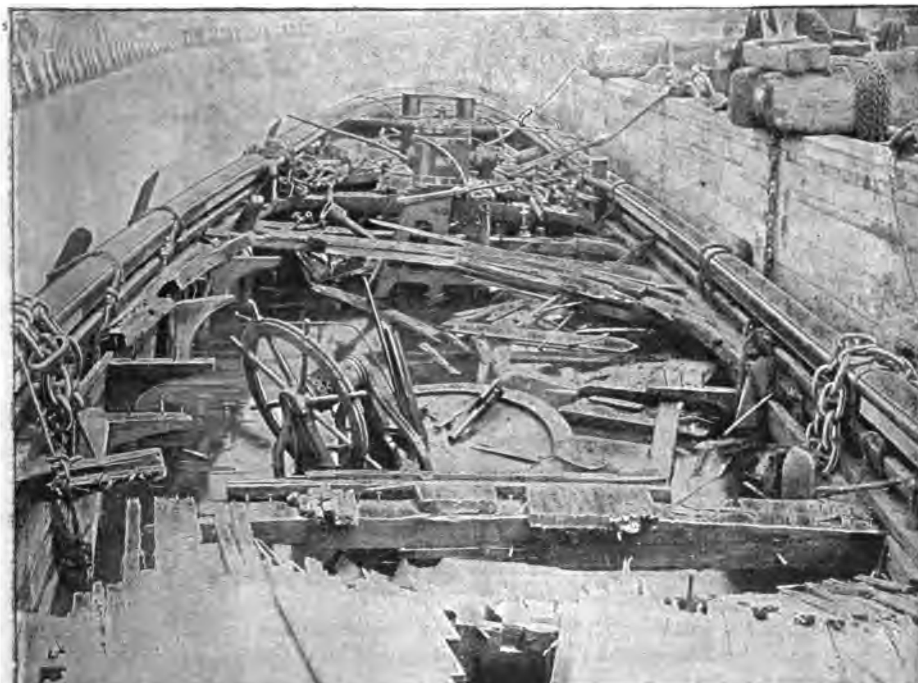

FIG. 1. — THE "RAMBLER" AFTER THE EXPLOSION.

tain Hewitt, who were to go down the bay on a pleasure excursion. Owing to some very fortunate miscalculation the expected party missed a train at Hartford, and were obliged to wait over until after the explosion. Except for this incident they would have been on the boat at the time the boiler blew up, and would undoubtedly have been killed. While awaiting the arrival of the party the captain of the *Rambler* had gone to the office of her owners, and the fireman was away after some paint. About fifteen minutes before the explosion the engineer of the *Rambler*, Mr. William H. Weimer, went aboard the tug *Thomas J. Walsh*, which was secured to the same dock. The only person remaining on the *Rambler* was Mr. Frederick W. Wells, who was steward, and who, at the time, was frying doughnuts.

The explosion wrecked the *Rambler*, blowing the upper part of her to atoms, some of the fragments being afterwards found at immense distances from the dock where the boat was moored. The hull was not damaged so much, but a hole was opened in it and the vessel sank almost instantly. Fig. 1 shows the appearance of the *Rambler* after

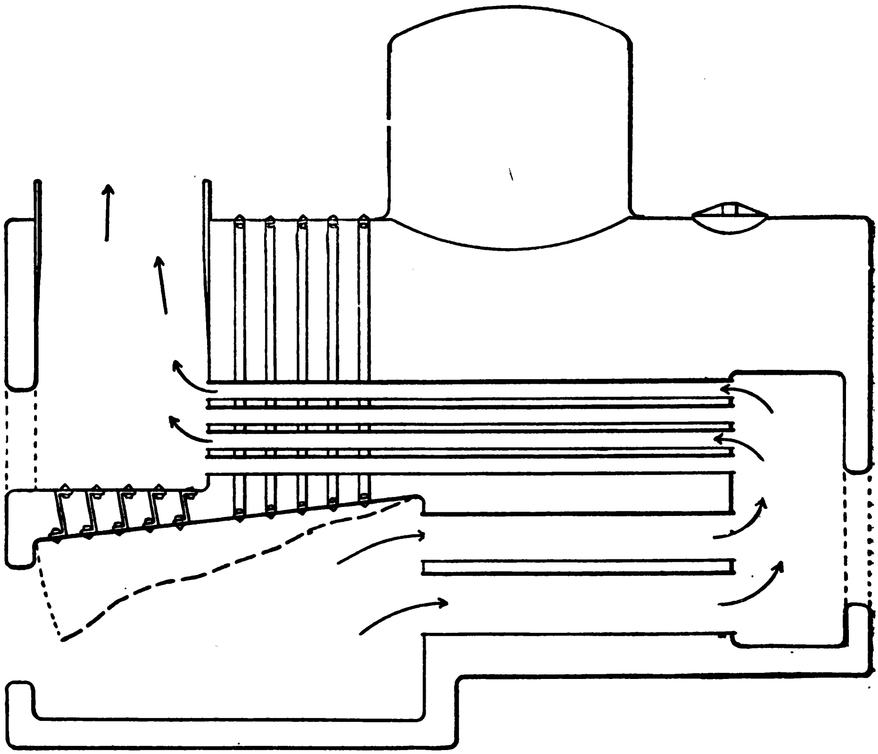

FIG. 2.—SECTIONAL VIEW OF THE "RAMBLER'S" BOILER.

she had been raised from the bottom. Engineer Weimer and Merritt Carney, the assistant engineer of the *Walsh*, were sitting on the deck of that vessel, near the stern. Both men were very seriously scalded about the legs, and Carney was also scalded on the body. They were removed to the hospital. Weimer was blown into the water. Patrick O'Hara, who was unloading railroad ties 150 feet away, was struck in the head by a flying scrap of iron, and a fellow laborer named Harrigan was also injured by a piece of wood. Both of these men will recover, however. The body of the unfortunate steward, Wells, was not found for several days. It was eventually found in the water, near the scene of the explosion. It was found that every bone in his body was broken, although there were no external marks of injury except a slight bruise on his forehead, over the right eye. It is probable that he was killed instantly by the concussion. He was a genial man, and well thought of by those who knew him. He was a single man, but was to be married in a month or so.

The boiler of the *Rambler* is shown in section in Fig. 2. It contained two furnaces,

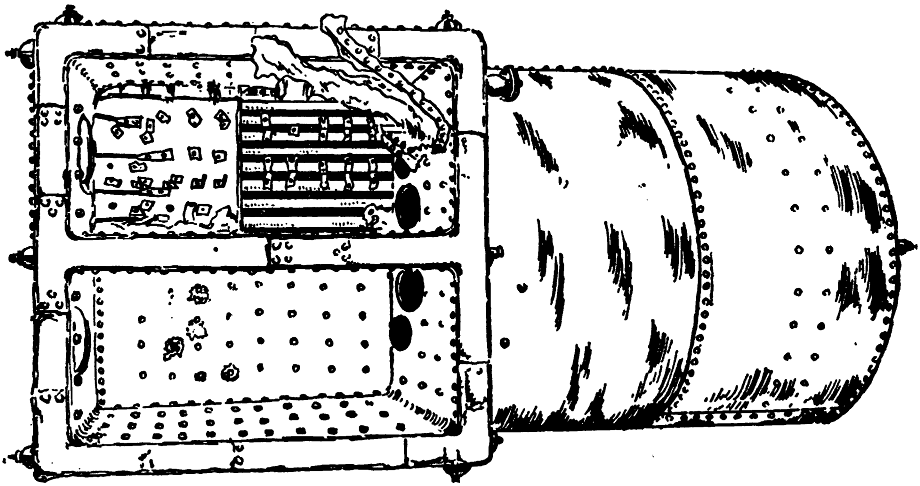

FIG. 3. — THE EXPLODED BOILER, SEEN FROM BELOW.

which were separated by a water-leg. The explosion was caused by the failure of the crown-sheet of the right-hand furnace, as indicated by the heavy dotted line in Fig. 2, and shown in detail in Fig. 3, which is a view of the exploded boiler as seen from below. An examination of the boiler indicates that the explosion was due to improper and defective bracing of the crown-sheets, especially of the one over the starboard furnace. Five of the braces at the right-hand rear corner of this crown-sheet had the appearance of having been broken for a considerable time, and three others had been nearly broken off at some previous time. This left an unbraced area of about 252 square inches. About two feet beyond these, there were three braces which were made straight, 2″ × ½″, with the lower ends riveted to the side or quarter radius of the fire-box crown, and the upper ends twisted through a quarter turn and secured above by pins to two angle irons that were riveted to the wagon-top of the fire-box. Two of these, and one similar brace near the front, appeared to have had no pins before the explosion. The plate first parted at the unbraced area mentioned above, where the braces had been broken previously. The rupture passed across the top of the fire-box to the front, and the front half of the crown-sheet was torn out bodily, and has not been found. Of the

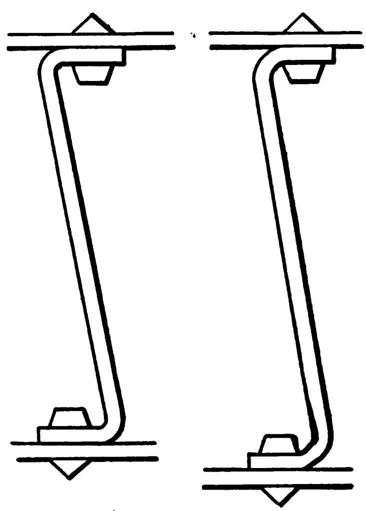

FIG. 4.— ILLUSTRATING THE ACTION OF Z-BRACES.

rear half of the crown-sheet one part turned up, and the remaining portion turned down to the side of the fire-box. There was no indication of low water. The safety-valve was so wedged into the débris that we could not get at it for examination. Engineer Weimer stated that there was plenty of water in the boiler, and that the steam-gauge indicated 80 pounds.

It will be seen from Fig. 2 that flat Z-braces were used on the crown-sheet. This form of brace is inherently weak, and should never be used for such purposes. The solid crow-foot brace is superior to it in every way. In Fig. 4 we present two views of the Z-brace, which will illustrate the cause of its weakness. The left-hand view shows the brace as first put in, while the right-hand view shows what happens to the brace when a pull comes on it. The ends are drawn away from the sheets, and the brace straightens out and allows the crown-sheet to bulge outwards. In most cases this deflection of the crown-sheet will not be sufficient to cause an immediate fracture; but as the pressure in the boiler varies the brace will bend back and forth, and in the course of time it is almost certain to crystallize and fracture across the line of greatest bending. This action is well illustrated by the common process of breaking a wire by repeatedly bending it back and forth with the hands. The action in the case of the Z-brace is precisely the same, and that is why we say that this form of brace is inherently weak.

Inspectors' Report.

MAY, 1894.

During this month our inspectors made 8,142 inspection trips, visited 15,966 boilers, inspected 6,893 both internally and externally, and subjected 735 to hydrostatic pressure. The whole number of defects reported reached 11,613, of which 1,123 were considered dangerous; 35 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	891	45
Cases of incrustation and scale,	2,225	63
Cases of internal grooving,	93	9
Cases of internal corrosion,	698	37
Cases of external corrosion,	873	62
Broken and loose braces and stays,	245	96
Settings defective,	345	37
Furnaces out of shape,	418	18
Fractured plates,	368	73
Burned plates,	203	12
Blistered plates,	286	11
Cases of defective riveting,	1,134	45
Defective heads,	91	16
Serious leakage around tube ends,	1,950	345
Serious leakage at seams,	415	35
Defective water-gauges,	381	58
Defective blow-offs,	168	54
Cases of deficiency of water,	13	6
Safety-valves overloaded,	70	23

Nature of Defects.	Whole Number.	Dangerous.
Safety-valves defective in construction,	76	29
Pressure-gauges defective,	573	38
Boilers without pressure-gauges,	5	5
Unclassified defects,	92	6
Total,	11,613	1,123

Boiler Explosions.

MAY, 1894.

(100.) — A boiler exploded in Compton, near Los Angeles, Cal., on May 1st, instantly killing Alonzo Claus, who was the engineer. C. C. Johnson, who was working near by, was seriously injured about the back and neck, but at last accounts he was not considered to be in immediate danger of death. W. A. Beck also received injuries about the head. The boiler was blown into a hundred pieces.

(101.) — Two large boilers at Robertson & Goodwin's mills, at Williamstown, near Raleigh, N. C., exploded on May 1st. There were fifteen persons in the building at the time, and all of them were injured, ten being caught by the falling timbers. Isaac Bright was dead when his body was reached, and four others were said to be dying. One of the boilers was torn into small fragments, and the other was blown thirty yards from its sitting, part of it going through a steamship warehouse 100 yards away, while other fragments were found three hundred yards from the scene of the explosion.

(102.) — On May 2d a cooking boiler exploded in Mr. G. B. Gehlert's vinegar factory, Bloomington, Ill. The exploded boiler was upright, fourteen feet high, and five feet in diameter. It was used for cooking corn, preparatory to fermenting it for the manufacture of alcohol and acetic acid. It had just been filled with corn, and 55 pounds of steam had been turned on, when, in a few minutes, the explosion occurred. Herbert Crapps, the fireman, was pinned down by timbers, and was enveloped by the escaping steam and boiling water. He was horribly scalded, and it seemed impossible that he could live. At last accounts, however, there was considered to be some slight chance of his recovery. Mr. Joseph T. McCrillis, the distiller, was slightly injured. A heavy section of pipe was thrown 150 feet, and the ground was covered with corn to a considerable distance, some of the grain being found 500 feet away. The building was considerably damaged, the property loss being about $2,000. There was a boiler explosion in this same mill in 1860, by which the engineer was killed.

(103.) — A boiler exploded on May 7th, at Dalton's pickery, Morgan City, La., blowing away the roof and two sides of the building, and setting fire to the ruins. The total loss is estimated at $15,000.

(104.) — In the town of Cyclone, five miles south of Frankfort, Ind., a boiler exploded on May 7th, killing William Spray, the owner of the factory in which the boiler stood. James Durben was also fatally injured, and several other employes received lesser injuries. The factory was completely wrecked.

(105.) — On May 8th, a boiler exploded at the Humphrey Glass Works, in Steubenville, Ohio. The entire west end of the factory was torn down, and the whole interior of the building was wrecked. Mrs. Sarah Smurthwaite's house, adjoining, was also shattered, and Mrs. Smurthwaite was seriously injured. Her son, Jacob, and her daughter and her baby were badly wounded also.

(106.) — A boiler exploded on May 8th, in the town of New Paltz, N.Y. There was plenty of water in the boiler at the time, and the steam pressure was 60 pounds, although it had been 80 pounds but a short time before. Mr. Ridgeway Lefever had his nose broken, and Harry Enderton was hurt about the back. Another man, whose name we did not learn, was burned about the face. The entire crown sheet of the boiler was torn out, and the building in which it stood was totally wrecked.

(107.) — One of the boilers used to generate steam for the vulcanizing of bicycle tires, in the rubber works at Akron, Ohio, burst on May 14th. The head of the boiler blew out, under a pressure of 45 pounds. Just opposite the exploded boiler is the "wringer-roller" room, and a portion of the brick wall of that room was blown out, and bricks were scattered in all directions. The boiler was a total wreck. There was nobody in either room at the time of the explosion, so that there were no personal injuries nor fatalities.

(108.)— On May 15th, a boiler exploded at the Dorr brickworks, Princeton, Ky. The explosion is said to have been due to the accumulation of sediment on the bottom of the boiler. Nobody was hurt.

(109.) — The boiler of the pump that supplies the Louisville & Nashville Railway tank at Paris, Tenn., exploded on May 16th, completely demolishing the building. Nicholas Purath, who has been in the employ of the company for twenty years, was fearfully scalded, and it is believed that he will die. The boiler was found nearly half a mile from the scene of the explosion.

(110.) — A boiler exploded on May 18th, in F. C. Ross's mill, at West Bay City, Mich. The engineer, George Closson, was killed instantly, and John Scareth was so seriously injured that he will die. Charles Scareth was fearfully bruised about the head and body, but he will probably recover. John Gregg was badly scalded about the face, neck, and right arm, and his hip was dislocated. His condition is serious, but he will recover. William Neal and his son, William Neal, Jr., were injured by flying debris. We have not seen any estimate of the loss on the building, but it is said that the machinery was damaged to the extent of several thousand dollars.

(111.)— A boiler at the Carbondale mine, a few miles southwest of Des Moines, Iowa, exploded on May 21st, injuring the engineer so seriously that he died a few hours later.

(112.)— On May 21st a boiler exploded at Eagle avenue and One Hundred and Fifty-eighth street, New York city. The men were about to begin work in the morning, and just as engineer John Crowley was about to open the stop valve, the fire-box sheets gave way, and the boiler soared into the air like a rocket, and came down through the roof of a stable, 300 feet away. Engineer Crowley and Michael Cannon were seriously injured, and were taken to the Fordham hospital. Each had his left thigh broken, and Crowley was also badly scalded. Patrick Toher, Charles Farrell, and Harry Williams, were cut and bruised, but they were able to go to their homes after their wounds were dressed.

(113.)— The boiler of Harris's mill, near De Funiak Springs, Fla., exploded on May 22d. The fireman, J. H. Davis, was instantly killed. John Cody, one of the mill hands, received injuries about the head that will probably prove fatal, and Henry

Scott's collar-bone was broken, and he was badly scalded and cut about the head. Two other hands received painful scalds and wounds, also. The mill was almost entirely wrecked. The boiler fell some 200 feet away.

(114.) — A boiler explosion that came near being followed by disastrous consequences occurred on May 24th, at the Lehigh and Wilkes Barre mine shaft No. 5, at South Wilkes Barre, Pa. One of the boilers that operated the cages and the fan exploded, leaving some hundreds of miners exposed to the gases below, as well as a party of seventeen or eighteen visitors from the New York Retail Coal Exchange. The incident terminated happily, for the four firemen who were near the exploded boiler escaped with trifling injuries, the workmen below, being familiar with the mine, got out safely, and the seventeen visitors reached the surface of the ground by climbing a thousand-foot ladder. One account gravely remarks that "the party [of visitors] made no further inspection of the coal mines in this vicinity, but returned to the Wyoming Valley Hotel, cleaned up, and took an early train for Scranton."

(115.) — On May 24th a boiler exploded in the East End power house of the Royal Electric company's plant, on Water Street, Montreal. One wall of the building was blown out, and a foreman was slightly injured.

(116.) — By the explosion of a boiler at the Hutchinson, Iowa, electric light plant, on May 25th, three men were instantly killed and one was fatally injured. [This is quoted from the Lansing, Mich., *Democrat.* We presume Hutchinson, Kan., is the town intended.— Ed.]

(117.) — At Sackett's stone quarry, near Ottawa, Canada, a boiler exploded on May 28th. The fireman, J. Beckwith, had three ribs broken and was frightfully scalded. He will die. Homer Sackett, the owner of the quarry, had his legs broken and his body bruised, by flying fragments of the boiler.

(118.) — A heating boiler exploded on May 28th in Lyons & Altingers's barber shop, in Kansas City, Mo. A number of men were present at the time, but all escaped injury.

(119.) — A boiler exploded on May 31st at Henry Lancaster's shingle mill, near the summit of the Santa Cruz mountains, Cal. George Robertshotte of Los Gatos was standing near the boiler when it blew up, and although fragments flew in nearly every direction, and the end of the mill was blown out, Robertshotte escaped injury.

(120.) — On May 31st, a boiler exploded in the Haines mill, at Circleville, Ohio. Joseph Shewler and Sherman Waite were killed outright, Willis Waite had both legs broken, and Samuel Sullivan suffered a fracture of one leg. The injuries of these men are considered very serious, and they may prove fatal. The shock of the explosion was terrific, and the report was heard for miles. A similar explosion occurred near this place a year ago, killing four men.

We have received, from the Lidgerwood Manufacturing Company, of 96 Liberty street, New York, an attractive illustrated pamphlet, or booklet, called *Cableway Sketches.* It is intended to exemplify the application of their cable haulage system to quarrying, mining, lumbering, bridge and dam building, coal handling, and engineering operations of all kinds. The illustrations are very creditable and suggestive. Most of them are from photographs of the actual apparatus.

The Locomotive.

HARTFORD, JULY 15, 1894.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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A RECENT boiler explosion at Tarkio has caused a much better attendance at prayer-meetings in that town.— *St. Joseph* (Mo.) *News.*

A SIX-INCH steam pipe burst on May 2d, in the plant of the Southern Electric company, at Philadelphia, Pa. Larry Martin, the night engineer, was scalded and burned so badly that he died almost instantly. John Touhy, a night lineman, was fatally scalded about the face and body, and Fireman John Fife, and Assistant General Manager A. H. Bowen were also painfully but not seriously scalded.

Congressional Ventilation.

By this heading we do not mean the ventilation of ideas, for no one can reasonably doubt that there is a sufficient amount of that. We refer to the supply, not of wind, but of air for breathing purposes. Few persons know of the extensive machinery used for the ventilation of Congress, and we thought the following extract from a recent issue of the Hartford *Times* might be of interest: "For the House of Representatives alone sixteen steam fans are employed, the biggest of them being 16 feet in diameter, and resembling the paddle-wheel of a steamboat. Standing in one of the tunnels in the basement of the Capitol, through which an artificial breeze rushes continually at the rate of twenty-six miles an hour, one feels unpleasantly chilled during the hottest hours of a summer day. When the galleries are crowded every member and spectator in the house is provided with sixty cubic feet of fresh air every minute. In order that the air thus supplied shall contain the proper amount of moisture it is made to pass through stone-lined compartments, where fountains of spray are kept perpetually playing."

AT the request of certain citizens of Gahanna, Ohio, the state inspector of shops for Ohio recently ordered an inspection of the boiler in the Gahanna flouring-mill. We quote the report of the inspector, as given in the Columbus *Press:* "We found over the fire grate quite a bulge, the sheet being sagged down 4 or 5 inches at the bottom of the boiler. In the rear a nipple screwed into the boiler, used as a blow-off, is very much crowded [?] The flues are so coated with lime that the ends are burned off, leaving them loose and thin. The braces in the boiler are loose and not of sufficient strength to support the heads of the boiler under pressure. The front supports of the boiler are broken, rendering them too weak to support the boiler safely. The glass gauge is small and not reliable, and there are no pop gauges [*i. e.*, try-cocks ?]" The report then proceeds to say that the breeching is worn out, that the stock is broken, and that the boiler, on the whole, is in a very unsafe condition, and quite beyond repairs. The report closes as follows: "We consider that you have been extremely fortunate that you have not had an explosion causing great damage and perhaps loss of life, thereby laying yourself liable to heavy damages."

We suppose the owners of this boiler thought it was all right, and that it was still good for years of service. The inspection has no doubt opened their eyes to the facts, and we presume the defective boiler has already been replaced by a new one. Leaving the life question entirely out of consideration, it is a poor financial policy to run a dangerously defective boiler for a single hour.

It would be difficult to convince the average man that fir is a stronger wood than oak, but such has been proved to be the fact by actual tests that were made by a fair and impartial committee appointed for that purpose. The timbers used were each 2 by 4 inches, and four feet long, both ends being solidly braced, and the weight applied in the middle of the span. Yellow fir stood a strain of 3,062 pounds, and common Oregon oak 2,922 pounds. Fine-grained yellow fir from near the butt stood a strain of 3,635 pounds, and best Michigan oak snapped with a strain of only 2,428 pounds. The tests were made by the Northern Pacific Railway Company, at Tacoma, Washington.—*St. Louis Republic.*

Obituary.

Mr. Thomas O. Enders.

It is with profound regret that we announce the death of Mr. Thomas Ostram Enders, who passed away at his home in West Hartford on June 21, 1894. Mr. Enders was born at Glen, N. Y., on September 21, 1832, and in 1854 he removed to Hartford, Conn., where he entered the employ of the Ætna Life Insurance Company as a clerk. Four years later he was elected secretary of that company; and in 1872, upon the death of the Hon. Eliphalet A. Bulkeley, he was elected president, which office he filled with distinction until his voluntary retirement in 1879. In 1881 Mr. Enders was elected president of the United States Bank, in which office he continued until 1892, when failing health compelled him to retire. Owing to his wonderful executive ability, his knowledge of finance, and his sound business judgment, his counsels were earnestly sought by the financial institutions of this city, and for many years he was a director in the Ætna Life Insurance Company, the Ætna Fire Insurance Company, the United States Bank, the Dime Savings Bank, the Society for Savings, and the Charter Oak National Bank. He was also a director in the Hartford Steam Boiler Inspection and Insurance Company, since its earliest days. Mr. Enders was esteemed and honored by all who came in contact with him, and his death is an irreparable loss to the community. At a meeting of the directors of the Hartford Steam Boiler Inspection and Insurance Company held July 2, 1894, it was voted that the following minute be spread upon the records of the company, that it be published in the daily papers, and that a copy be sent to the family of the deceased:

"It is with deep sorrow we record the death of Thomas O. Enders, who has been connected with this Board for nearly twenty-seven years, having been elected a member July 8, 1867. The company had just entered upon a new and hitherto untried class of insurance, and many doubts were expressed as to its ultimate success. Mr. Enders's faith never wavered. He firmly believed that an enterprise which had sound underlying principles would succeed with well-directed effort and honest management. His wide experience in insurance and financial lines rendered his counsel and advice invaluable. This occasion recalls the early meetings of this board, when methods of management were discussed and the foundations of ultimate success laid. As an associate, Mr. Enders was kindly in his bearing, sympathetic and courteous to all, and his life and character have made an enduring impression upon those who were brought into intimate official relations with him. We record this minute as a tribute to his memory and as a mark of our high esteem for his life and character. C. C. KIMBALL, *Clerk.*"

Power Rental.

The following article on this troublesome question is from our esteemed contemporary, *Engineering* (London). In reproducing it we have reduced the items of expense and income to their American equivalents, assuming the English pound equal to $5. Some of the estimates do not correspond with the facts in this country — the wages of the fireman, for example, — but, nevertheless, we think readers of THE LOCOMOTIVE will find the article interesting and suggestive:

"The rental of factories and of power is perhaps not so common now as it was forty years ago, when it frequently obtained, particularly in the Manchester district. Nasmyth relates in his autobiography that he started work on his own account on the upper floor of a mill, the other floors of which were let to separate tenants, and the power for driving the machinery on all the floors was supplied from one engine at a fixed rental. The practice was particularly convenient in the case of a young man going into business on his own account with but a limited capital, but it was not free from objections, as the interests of the different tenants might happen to clash. In fact, this was what occurred in Nasmyth's case, as some of his heavy castings came through the floor one day and smashed up the goods of a glass-cutter, who occupied the floor below. This incident led to a termination of Nasmyth's tenancy, and to the establishment of his well-known works at Patricroft.

"When power is rented in this way, the question arises as to what is a fair price to charge for it. This depends upon several conditions, and a rate which may be perfectly fair for a small amount of power is excessive when greater amounts are taken. At the Chicago Exhibition, where the plant was on the largest scale, steam power was supplied at the rate of $40 per horse-power for the six months during which the Exhibition was open, and electric power at rates varying from $120 to $50 per horse-power, according to the quantity taken. As the plant was a temporary one the fixed charges were naturally high; but as it was also carried out on a large scale, it is probable that these prices paid very well. This case, however, corresponds rather to such a system of power supply as that of the London Hydraulic Power Company, or the Paris compressed air system, than to the rental of the floor of a factory to which the power is supplied from the main engine. This last case has been discussed pretty fully by M. V. Dubreuil in a paper read before La Société Industrielle du Nord de la France. The rate at which power can be rented in such a case will depend mainly upon the rate at which the proprietor can produce it; for, although a horse-power is of the same value to the tenant whether it be generated by a simple slide-valve non-condensing engine or by a compound Corliss engine of the most efficient type, he cannot expect to get it at a cost less than that of production. This cost of production will depend upon the cost of the engine, boilers, and accessories, and on the cost of shafting, etc. For a simple slide-valve engine M. Dubreuil considers that the cost of engine-house foundations, first-motion shafting, piping, and safety-gear, may be taken as 65 per cent. of the cost of the engine; while for compound engines the cost of these accessories will amount to 50 per cent. of that of the engine alone. The cost of the boiler-house, piping, and fittings, may be taken as equal to the cost of the boilers themselves. To these items must be added the cost of external piping, condenser, tanks, chimney, etc., which will add another 20 or 30 per cent. to the combined first cost of engine and boilers. He considers that a fair approximation to the capital cost of engines as erected can thus be arrived at, but there has to be added to this the capital cost of the means of transmitting the power from the engine-house to the machines. In the case of a weaving-shed, M. Dubreuil takes this at from $15 to $20 per loom, and for spinning at from 8 cents to 12 cents per spindle. On all this plant 10 per cent. is not too high an annual rent to demand when the necessity of maintenance is considered. A further capital sum to be considered is the value of the land occupied by the boiler and engine-houses. On this 5 per cent. would be a fair rate of interest, as it is not subject to the same depreciation as the rest of the capital account.

"Hence, if we consider a 100 horse-power simple engine of good type, the capital account will work out about as follows, according to M. Dubreuil (whose prices, however, do not always agree with English experience):

Cost of engine,	$4,000
Cost of foundation, etc. (65 per cent. of $4,000),	2,600
Cost of boilers,	2,400
Cost of boiler-house, piping, etc. (=cost of boilers),	2,400
Accessories (30 per cent. of cost of engine and boilers),	1,920
Transmission gear, say	5,000
Total first cost of plant,	$18,320
Value of the land, say	$800

The annual expenses will then be:

Ten per cent. on $18,320,	$1,832
Five per cent. on $800,	40
Wages of fireman,	325
Sundry stores (oil, etc.),	300
Water,	80
Coal,	1,500
Total annual expense,	$4,077

"The annual cost of 100 horse-power to the proprietor is thus about $4,077, or $40.77 per horse-power; and, including the proprietor's profit, the cost to the tenant should be about $45 per horse-power per annum, as measured at the engine cylinder. M. Dubreuil holds that only about 45 per cent. of this will be received at the machines, so that if the power is measured there, the tenant must pay $100 per effective horse-power per annum, if the owner of the factory is to get a fair return for his risks."

Concerning Inspections and Explosions.

For some reason or other "Constant Reader," "Pro Bono Publico," "Justice," and other correspondents of the daily press whose letters appear in the "People's Column," have recently taken a considerable interest in boiler inspection. Other writers, bolder than these and sometimes fully as aggressive, come out with their true names, and each elucidates the subject of boiler explosions, and also inspections and other cognate matters, from what seems to him to be the right point of view. We do not question in the least the good faith of these gentlemen; but we believe that their conclusions are usually founded on insufficient data and on imperfect observations. Here is an article, for example, which was recently written for the Albany (N. Y.) *Argus* by Mr. S. W. Snyder:

"Much has been said and written on the causes of boiler explosions and the danger of using an unsafe boiler, or one that has been condemned by an inspector, who too often knows no more about it after an inspection than before, and nine times out of ten he simply takes a hammer and strikes the fire surface plates a few blows, and if any show signs of a dent, then the inspector at once cries out 'dangerous,' when it is just as good (in the hands of a safe man) as a new boiler that has just stood a No. 1 cold water pressure test [!]. There are two, and two only, causes of a boiler explosion, and in order to get up a first-class boiler explosion you must have a first-class strong boiler, and the explosion will deteriorate in the same ratio as the boiler weakens, and if any inspector should say that *any* boiler would be unsafe in the hands of a 'safe man,' I should say that he had better be employed in street sweeping. Now, what are the two causes of a boiler exploding? The principal cause is letting the water get out of the boiler or below the lower gauge, and then, in order to save his position, the engineer takes his chances and pumps water into the boiler, and this, coming in contact with the red-hot plates of the fire surface, generates a 'gas' that is a hundred times more explosive than giant powder, up goes the boiler and up goes the water-tender with it. The boiler lands near or far, according to its strength, and where the water-tender lands finally depends on the manner of his life. Nine out of every ten boilers 'go up' from this cause. The only other cause of an explosion is carrying too great a pressure of steam, which is as easily avoided, by having a safe man in charge of it, as the other.

"Every boiler, when made, is tested (or should be) by cold water pressure, and this is supposed to be greater than it is subjected to afterwards. Of course, this constant strain upon the boiler weakens it, but *the more the boiler weakens, if tended by a safe man, the less dangerous it is* [*!!*]. Now, if this be the case, why is it necessary to inspect a boiler? Well, it is not, unless it is inspected right, and the proper way to do this is as the original inspection was conducted — by cold water pressure — and any inspector well up in his business can tell just how far he can carry the pressure without straining the boiler. When this test is made properly, the inspector should, by law, set the safety-valve and have power to lock the box on the rod of the safety-valve, at least at ten pounds less pressure to the square inch than indicated by the inspection. Register the pressure indicated, and make it a crime for any one to move it. If a lower rate of pressure is needed the water-tender can regulate it by the pump [?], but he can never carry a head of steam above the safe limit. This would make the poorest boiler more than safe.

"The average citizen knows a great deal less about a boiler than he does about his mother-in-law, but is in about the same dread of both. When there is a fearful boiler explosion, causing great loss of life, the boiler traveling from the basement up through three stories out through the roof, and fragments landing from a quarter to a half-mile from the position it formerly occupied, it is very amusing, when the coroner empanels a jury to view the remains of persons and boiler also, to hear these smart men at once condemn the boiler, saying it was a poor boiler and should not have been allowed to run; whereas, if they had known the least thing about it, they would have known that to make such havoc it must be a good boiler. This shows just how much reliance can be placed upon a verdict from such men as these. A case in point: At five o'clock one summer morning, just as the day shift was going to work at the Tredegar Iron Works, Richmond, Va., a terrible explosion occurred at a paper mill, two blocks away. No sooner had the noise died away than we rushed to the scene, and found that the boiler had left the building in two sections, one going up through the roof and landing in front of the depot, the other having been carried into the heart of the city. Three men and one woman were killed outright. A jury was summoned and did as all juries do in similar cases — condemned the boiler as worthless. The mayor of the city was present at the inquest, and when the verdict was rendered, I said: 'That jury knows nothing about boiler plate. There was no better boiler than that in Richmond yesterday.' I called his attention first to the fact of the great ruin it had caused, saying a poor boiler could never have gotten out of the building, and also directed his attention to the fracture and showed him how loath the boiler was to part, for the fibers or threads were sharp as needles, and then, at my request, the mayor and jury accompanied me to the works, and I cut the condemned plate in strips three inches wide and piled one on the other until I had a three-inch square pile, put it in the furnace and subjected it to a welding heat, rolled it into a half-square and, as one of the jury was a blacksmith, gave him a piece to break, but he found it impossible to do so. A few days after, when the watchman of the building was able to talk a little bit, he said he had gone into the boiler-room, found the water-tender asleep, which, of course, tells the old, old story. When he awoke fully, he tried his gauges, found no water, took the chances, pumped, and up both went.

"Now, what mischief will a very poor boiler do? Well, just none at all. At the Albany iron works in 1866, the boiler connected with No. 2 puddling furnace sprung a leak. The fires were drawn in the furnace and the brick man-holes were knocked in, and it was discovered that a sheet in the center of the boiler and also in the center of the fire surface had cracked, and that the water was leaving the boiler quite rapidly. When the boiler was cooled the man-holes of the boiler itself were removed and a boiler-maker, with a hammer in his hand, entered; and so poor was this boiler that he found no trouble throwing his hammer through any of the plates of the fire surfaces, so thin and rotten had they become. And this boiler was rendered perfectly safe by having a man tend it that knew his business.

"What, then, will render any boiler perfectly safe? Answer: By having a safe, careful man, who knows his business, tend it. S. W. SNYDER."

There are some astonishing ideas advanced in this article. What a singular inspector it must have been, who pounded *ad libitum* on the fire sheets, and then looked for dents! If Mr. Snyder had said that *this* man was eminently qualified to be a street sweeper, we should very likely have agreed with him; though it is just possible that we should have held that such a man's true forte is the clam business. Of course it is a truism to say that no boiler could explode when under the care of a "safe man" — a "safe man" being defined as one who can keep it from exploding. The only serious trouble about this is, that when a weak boiler is under consideration there is no such person living as a "safe man," in Mr. Snyder's sense of the word. Upon this gentleman's theory, we fail to see any reason for having a factor of safety in boilers. Why not make them just strong enough to hold together under the maximum working pressure? Then if they get blown up by these mysterious, irresistible gases and things that Mr. Snyder tells about, there will be the least possible damage done. We understand that, on his theory, such a boiler would be quite as safe, under ordinary running conditions, as a boiler with a factor of safety of 500 or so — provided you could find the hypothetical "safe man" to run it. We thought the low-water theory of explosions was itself exploded, long ago. Of course low water can cause a rupture, by the overheating of the plates and the consequent destruction of their strength; but we thought it had been pretty well established that the energy in a cubic foot of hot water is vastly greater than the energy in a cubic foot of steam at the same temperature, and that when a particularly disastrous explosion occurs, the damage wrought by it is in itself good evidence that there was plenty of water in the boiler. As we have already said, we believe that Mr. Snyder is thoroughly in earnest, and that he honestly believes his teachings; but nevertheless we hold these teachings to be dangerous, because our experience indicates that they are certainly in error.

The following letter, in answer to Mr. Snyder, was sent to the *Argus* a few days after the publication of the one we have quoted:

"In your issue of last Sunday you published an interesting article on 'boiler explosions,' signed 'S. W. Snyder,' and so far as his suggestion of employing 'safe and good men' to have the care of steam boilers goes, I entirely agree with him; but I think he is wrong in some of his conclusions, especially so when he speaks of generating an explosive gas in a boiler. Will he kindly give us the name of the 'gas' so generated? In bygone years my head was filled with the explosive-gas theory, and other kindred causes of boiler explosions, but a study of scientific works on the subject quickly dispelled the illusion. I know that there are a great number of 'practical' men who have a hearty contempt for 'book learning,' but that commodity, coupled with a practical knowledge of mechanics, never did harm to its possessor, in my opinion. But to return to Mr. Snyder's article, I find that he ascribes as a reason for most of the boiler explosions the introduction of water upon hot plates, and I believe that he is in error in this, for I think an explosion most frequently occurs from a structural weakness of the boiler, especially when the latter is in the charge of an incompetent man. Many years ago, one Perkins — a New England man — produced a steam generator in which steam was formed by injecting water on red-hot plates, and not a single one of his generators ever exploded. About thirty years ago, a Reverend Mr. Mitchell of this city patented a revolving steam-generator embodying the same idea, and many of our old citizens had good reason for regretting the fact, but none of his generators were guilty of exploding. To go further back, over fifty years ago the learned Dr. Nott of Union college had a foundry in this city — located near the intersection of Washington and Western avenues of to-day — for manufacturing the celebrated Nott stove, and in the stack of the cupola he placed a water-tube boiler — which, I believe, was the first of a kind that has recently come into vogue — and it was a daily occurrence to have the water get so low in the tubes that they would get red hot, then the engineer would start his feed-pump, and the change of color of the tubes — from red to black — would indicate the level of the water in the boiler, but the boiler never exploded.

"The cause of boiler explosions remains as great a mystery as it was before the Franklin Institute of Philadelphia expended thousands of dollars, appropriated by the

United States government, to investigate such explosions, and were compelled to admit that they could not come to a satisfactory conclusion. WILLIAM H. LOW."

Mr. Low seems to have the right idea in this matter, except in his closing paragraph, where he seems to rescind an opinion expressed in the earlier part of his letter. He says that "the cause of boiler explosions remains as great a mystery as it was . . . ." Now we think that all men who have had large experience with exploded boilers will admit that there is no one CAUSE of boiler explosions. Each explosion has to be considered by itself, and the cause has to be deduced from an examination of the fragments of the boiler, supplemented by such other evidence or testimony as can be had. There are *multitudes* of causes of boiler explosions, and hence it is illogical to try to assign a single cause which should be answerable for all. Moreover, there are extremely few explosions whose causes cannot be found by an experienced man, when he is able to look the facts of the case over within a reasonably short time of the accident.

In closing this article we want to say that Mr. Snyder's method of testing boiler plate is the strangest we ever heard of. We don't know anything about the particular explosion to which he refers, but we cannot see what reason he had for supposing that the quality of the plate remained unaltered after cutting strips, piling them 8 or 10 layers high, raising them to a welding heat, rolling them "into a half square," and cutting them up into lengths. What was the matter with cutting out a strip near the fracture and testing this strip at once, and without further treatment, for tensile strength, ductility, and elastic limit?

IN a paper lately read before the American Society of Naval Architects and Marine Engineers, Mr. George W. Melville, engineer-in-chief of the United States navy, discusses the machinery of some of the latest American war vessels. The difficulty of obtaining a fairly economical engine, both at full power and at cruising speeds, is felt as keenly in the United States marine as in ours [England's]. In Gunboat No. 7 the following plan has been adopted: About two-thirds of the boiler power is obtained from water-tube boilers, which weigh only one-half as much as cylindrical boilers of equal capacity. The engine is designed for quadruplex working at full power, the steam being taken from the water-tube boilers at 250 pounds pressure. The cylindrical boilers, which make up the remaining third of the whole boiler power, are connected by a reducing valve to the first intermediate receiver. At reduced power the large low-pressure cylinders are disconnected, and the remaining cylinders worked as a triple-expansion engine, with steam pressure at 160 pounds per square inch, this steam being furnished by the cylindrical boilers. In the matter of forced draft Mr. Melville prefers to use a closed ash-pit rather than a closed stoke-hold, where this can be conveniently done, which is seldom the case in a war-ship, where a thorough ventilation of the stoke-hold is essential to prevent the atmosphere becoming impure. In the case of the *Brooklyn* and the *Iowa* Mr. Melville wished to get the requisite draft by using funnels 100 feet high, which he claims have several advantages over fan-draft. Within recent years the weights of both engine and boilers, per indicated horse-power, have been substantially reduced; in the latter case by the adoption of coil boilers, and in the former by using higher piston-speeds, and by substituting steel for the wrought and cast iron formerly used. By still further increasing the speed, and possibly by using nickel steel, Mr. Melville thinks that the weights of the engines may be still more diminished in the course of the next few years.—*Engineering* (London).

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Hand-Hole Guards.

It sometimes happens that a boiler manufacturer who has paid great attention to the more important parts of his boilers, fails to give due consideration to the small things about them that occasionally give trouble. One of these "small things" is the hand-hole guard; and as very little is said about this comparatively insignificant item in the books, we propose to offer a few words of advice about it in the present article.

The simplest form of guard that we know of is shown in Fig. 1; and this form, in our opinion, is also the best one for general use that has yet been proposed. It is often made unnecessarily heavy, but as this does not interfere with its efficiency, one could only object to the extra weight on æsthetical grounds; and it is hardly necessary to say that æsthetics and such mundane things as hand-hole guards have no business with each

FIG. 1. — COMMON TWO-LEGGED GUARD.

other, anyway. Moreover, it is better to have the guards too heavy than too light, because they will then be less liable to injury from burning.

The only strain that comes on a hand-hole guard is that which is put upon it at the outset in screwing up the nut so as to make the gasket tight. The steam pressure, by compressing the gasket, tends to relieve the strain on the guard, rather than to increase it. So far as strength is concerned, therefore, the two-legged form of guard is quite satisfactory. In days when boilers were made with $\frac{3}{8}$-inch iron heads, and gaskets were much harder than those now in use, it was found that when a two-legged guard was used, the head would sometimes spring enough to cause a slight leakage around those parts of the hand-hole that were furthest from the legs of the guard. A four-legged guard like that shown in Fig. 2 was therefore favored by many builders, and it was held that this form would prevent the plate from springing sensibly. If the four legs rested equally on the head there can be no doubt that this would be the case; but it is readily seen that it is no easy matter to secure this condition. If the head and the guard were carefully planed, or "surfaced," the bearing of the legs could be made practically perfect; but in actual practice we should find, in most cases, that two of the legs took all the strain, the others being of no particular use. Even if the guard were nicely fitted in one position, the chances are that the first time the fireman took it off he would turn it bottom side up, and then all the careful fitting would become useless. With steel heads, half an inch thick or thereabouts, and with reasonably small hand-holes, there should be no sensible springing of the head with the soft gaskets now in use; and this fact, combined with the extra difficulty of adjusting the hand-hole plate properly when

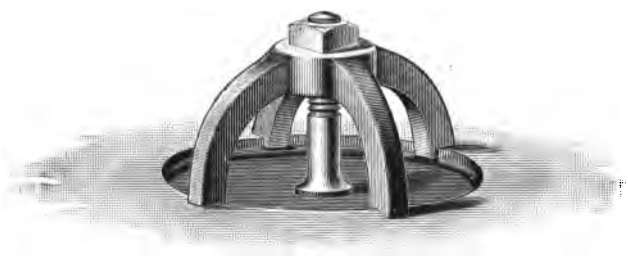

FIG. 2. — ILLUSTRATING THE FOUR-LEGGED FORM.

four-legged guards are used, seems to indicate that in all ordinary cases the two-legged form is quite as good as the quadruped variety.

In Fig. 3 we show a "ring-guard," a form which is now used much less than formerly. This style of guard is particularly objectionable. If there is any leakage around the hand-holes, or any occasional dripping from the tubes overhead, or any condensation of corrosive substances distilled off from the fire, the ring-guard is sure to show at its worst. The moisture or condensible matter from the fire is drawn in between the ring and the head, by capillary attraction, and then the head begins to waste away under the ring, as shown in section in Fig. 4. After a time this destruction of the edges of the hand-hole proceeds so far that the hole has to be cut larger; and if another ring-guard is put on, the same action continues. The time required for the destruction of the edges

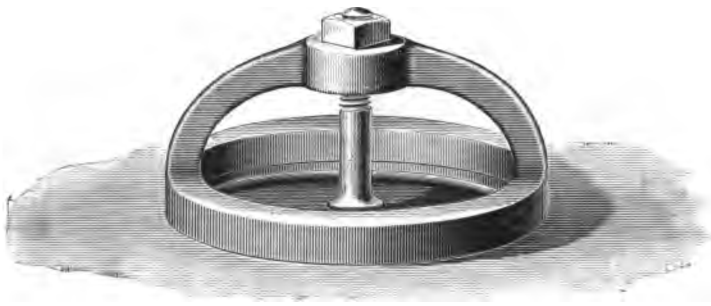

FIG. 3. — THE RING-GUARD.

of a hand-hole in this way will naturally vary with the conditions; with a new boiler it may be three or four years. The wasting does not necessarily take place uniformly in all directions; for if the hand-hole leaks a little, it will be found that the deterioration is most rapid along the lower part of the ring, where the escaped water collects. The hand-hole opening is usually cut as near the flange of the head as possible, for the double purpose of having it a sufficient distance from the tubes, and of having it as near the bottom of the boiler as practicable. It will be readily understood, therefore, that any further enlargement of the hand-hole along the lower side is apt to make trouble, because as soon as the hole reaches the flange it becomes impossible to make a tight joint without using some special form of plate or gasket; and special forms of plates and gaskets are objectionable, because the fireman, unless he is a pretty good man, is more or less apt to put them in wrongly, thus making matters even worse.

The engraver has shown the ring-guard (Fig. 3) as though there were considerable

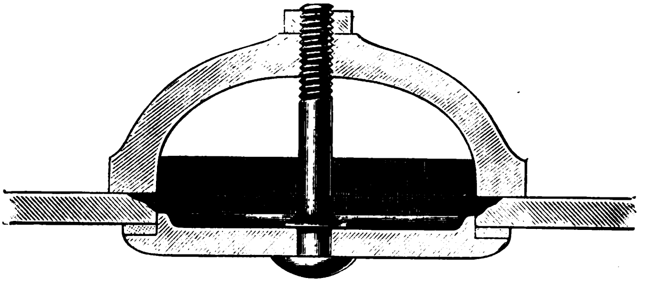

FIG. 4. — ILLUSTRATING THE EFFECTS OF THE RING-GUARD.

space between the ring and the arched rib through which the bolt passes. In practice this space is smaller than shown, and it is not an easy matter to put the hand-hole plate on properly when using a ring-guard, unless one knows the right way to do it. The easiest way, in our opinion, is this: Take a hitch about the bolt with a piece of string, and pass the string through the bolt-hole in the guard. Then put the plate into the boiler and bring it into its proper position. It can now be held by pulling on the string, and the guard can be slipped into position. The nut also can be passed over the string, or the string may be removed and the nut screwed carefully on by hand as far as it will go, the job being finished with the wrench.

If the bolt projects too far beyond the guard it is apt to burn so that the nut cannot be removed, the bolt twisting off before the nut slips on the thread. A preliminary

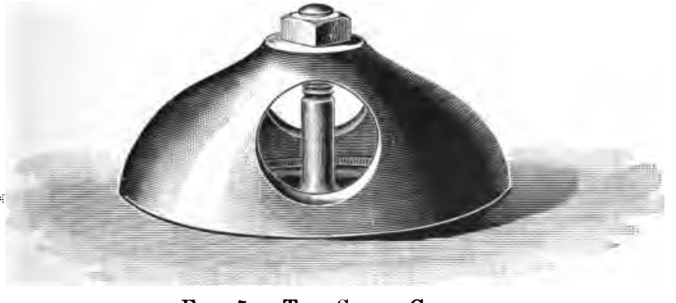

FIG. 5.— THE SHELL-GUARD.

application of kerosene to the nut often greatly facilitates its removal; and it is a good plan, when putting the plate on, to first apply to both bolt and nut a paste made of machine oil and black lead. To protect the projecting end of the bolt it is well to screw on a second nut; it will not matter if this second nut only catches one or two threads, as it is not intended to *hold* anything, its only purpose being to protect the thread of the bolt from the direct action of the fire. Another plan for protecting the bolt, which is often tried with good results, is to first make quite sure the hand-hole plate is tight, and then to cover up the nut, bolt, guard, and all, with a double handful of fire-clay. This soon bakes on and forms an excellent protective covering. It is readily removed by light blows of the hammer; and as steam or water will disintegrate it, it does not conceal leakages, nor promote corrosion by keeping the head of the boiler damp.

In Fig. 5 we show the old-style "shell-guard," which was probably first designed with the idea of protecting the bolt somewhat from the fire. The protection secured by it is slight, however, and as the objections that we have urged against the ring-guard apply to this form with even greater force, we consider the "shell-guard" to be the least desirable of all the forms shown in the present article.

Inspectors' Report.

JUNE, 1894.

During this month our inspectors made 7,467 inspection trips, visited 13,931 boilers, inspected 6,702 both internally and externally, and subjected 706 to hydrostatic pressure. The whole number of defects reported reached 11,308, of which 976 were considered dangerous; 25 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	840	35
Cases of incrustation and scale,	1,903	101
Cases of internal grooving,	118	12
Cases of internal corrosion,	630	33
Cases of external corrosion,	805	47
Broken and loose braces and stays,	160	25
Settings defective,	373	23
Furnaces out of shape,	487	21
Fractured plates,	273	35
Burned plates,	252	20
Blistered plates,	302	26
Cases of defective riveting,	1,600	29
Defective heads,	105	13
Serious leakage around tube ends,	1,656	356
Serious leakage at seams,	483	13
Defective water-gauges,	388	54
Defective blow-offs,	177	35
Cases of deficiency of water,	16	5
Safety-valves overloaded,	58	23
Safety-valves defective in construction,	67	26
Pressure-gauges defective,	525	38
Boilers without pressure-gauges,	6	6
Unclassified defects,	84	0
Total,	11,308	976

Boiler Explosions.

JUNE, 1894.

(121.) — On June 4th a boiler exploded at the Rankin & Wolfe brick and tile works, Tarkia, Mo. The head of the boiler blew out and passed through a partition and down through the roof of the drying room. The rest of the boiler went in the opposite direction, and finally landed about 250 feet east of the works, striking the ground several times on the way, and incidentally breaking a steel rail into three pieces. The roof of the boiler-house was completely wrecked, and most of it was carried away. The night fireman, Barney Roop, had gone from his accustomed place, out to the north end of the drying room; and this probably saved his life. The chair where he had been sitting was covered with debris. Had the works been in operation and the men in their places at the time of the explosion, several would doubtless have been killed.

(122.) — On June 4th a terrible boiler explosion occurred at an oil well in Montgomery township, near Rising Sun, Ohio. Half of the boiler was carried a distance of 500 feet. The fire-box end was thrown in the opposite direction to about the same distance, passing over a field of oats, and coming down in some woods. In landing, the fire-box felled to the ground one tree that was about 12 inches in diameter, and, rebounding, it damaged another at a height of some fifteen feet. Otto McIntire, the tool-dresser, was thrown 75 feet. He was scalded on the right side and was also badly bruised. He was said to be in a dangerous condition.

(123.) — Smith's drain-tile works, at Wilkinson, near Indianapolis, Ind., were totally destroyed by a boiler explosion on June 5th. Mr. Smith narrowly escaped death.

(124.) — A boiler exploded on June 5th at the Greenleaf-Johnson Company's mill at Howard, Bertie Co., N. C. Two men were killed instantly, and we understand that three more have died since. Four other men were seriously and perhaps fatally injured.

(125.) — On June 6th a boiler exploded on the steam tug *Rambler*, while she was tied up at Pocket Dock, New Haven, Conn. Frederick W. Wells, the steward, was killed instantly. William H. Weimer and Merritt Carney, who were on the neighboring tug *Thomas J. Walsh*, were painfully injured. The upper part of the *Rambler* was demolished, and a hole was opened in the hull, so that she sank almost instantly. Engineer Weimer is reported to have said that "the explosion was due to an undue generation of gas." We think the true cause was correctly stated in the July issue of THE LOCOMOTIVE, where this explosion was illustrated and described.

(126.) — A hot-water heater exploded on June 6th in a chair-car on an east-bound through train of the Chicago, Burlington & Quincy Railroad. Harvey Wright, a porter, was seriously injured, and it was said, at first, that a dozen passengers received slight injuries, though this was afterwards denied by the railroad officials. The accident occurred on the high bridge crossing Bureau river, one mile west of Princeton, Ill. The explosion was due to the corrosion and consequent sticking of the safety-valve.

(127.) — Two buildings, sixty feet long and thirty feet wide, were destroyed on June 8th by the explosion of a coil of steam pipe used in the soap factory at the insane asylum in Kankakee, Ill. The engineer and fireman narrowly escaped death.

(128.) — A terrific boiler explosion occurred on June 8th at Choptank, near Denton, Md., in Jesse A. Wright's shirt factory. The account says that "J. A. Wright, the proprietor, Will Towers, the engineer, and A. L. Dunham and John K. Watson, employes, were engaged in repairing the machinery before the regular work of the day began. The engine had been stopped and the attention of the men was entirely occupied by the work in hand. The rising steam in the boiler was forgotten, and considerable time passed before anybody looked at the gauge. The discovery was then made that instead of 85 pounds, the pressure had gone beyond the 140-pound mark. Almost instantly the crash came. The engine-house, which adjoins the factory, disappeared, and the cloud of roaring steam was pierced by flying iron and timber. Big pieces of the boiler were blown far into the river beyond the long piers, and part of the factory proper was wrecked. Mr. Wright and Mr. Towers were very seriously injured. The former was crushed about the legs, and amputation will probably be necessary. Mr. Towers was knocked down and mangled, and Messrs. Dunham and Watson were badly scalded. One woman in the factory was hurt. Mr. Wright's loss is heavy. The engineer will probably die."

(129.) — On June 12th a tube burst in one of the water-tube boilers at the Edison Electric Light Company's plant, in Columbus, Ohio. Nelson Secrist, a fireman, was stooping before the boiler at the time, pulling out ashes. The explosion blew the furnace door open, and Secrist was badly burned and scalded.

(130.) — A boiler exploded on June 12th in a mill near Linneus, Mo. The body of James Logue, a workman, was torn to fragments, and Aaron Logue was cut in twain. Michael Logue was blown into a tree-top, and every bone in his body was broken. William Kemper was also blown some distance and fatally injured. Pieces of machinery were driven several inches into trees, and the mill fixtures were scattered over a large area. A few months ago there was a similar explosion at this same mill.

(131.) — The boiler in Gossler & Co.'s mill at Deloys, near Cammal, Pa., exploded on June 13th, instantly killing the fireman and his little daughter. The boiler was blown into a creek about 75 feet away.

(132.) — On June 13th the head blew out of a boiler at the Oneida Carriage Works, at Oneida, N. Y. We have not learned the amount of the damage, but it was said that the works would have to lie idle at least a month. It appears that nobody was injured.

(133.) — A boiler belonging to W. H. Brown & Sons, at Elrod, Pa., exploded on June 16th, wrecking the building in which it stood. The accident occurred at the noon hour, while the men were at dinner, and nobody was hurt. Fragments of machinery were blown through the office.

(134.) — A kitchen boiler exploded on June 17th in the residence of F. G. Platt, on Grove Hill, New Britain, Conn. The stove was "blown into a thousand pieces," and the house was considerably damaged. Fortunately there was nobody in the kitchen at the time.

(135.) — On June 18th a boiler exploded in Bilger Bros.' saw-mill, on the side of Nittany mountain, just south of Pleasant Gap, Pa. Nelson E. Bilger, the engineer, was blown through a board wall, and his body fell in a mud-hole fifty feet away. He was killed instantly and horribly mangled. In fact, one account states that "not enough of it could be found for the coroner to hold an inquest on"; but that is not true. Herbert Bilger was badly scalded and bruised, but will recover. The boiler parted in the middle, one end of it flying 300 feet in one direction, while the other flew 200 feet in the opposite direction. The mill was blown to pieces. Eight workmen had just left the mill for the mountains, so that if the explosion had occurred a few minutes earlier the list of fatalities would have been more extensive.

(136.) — Two boilers exploded on June 19th at the Wells Roller Mills, Wells, Minn. Engineer George Baer was killed instantly, and the property loss is about $5,000 or $6,000. The mill is owned by W. H. Ketzlback & Co.

(137.) — On June 20th a locomotive boiler exploded at Hiawassa Station, Tenn., on the Marietta & North Georgia Railroad. Fireman James Devers was instantly killed. J. C. Devers, engineer, J. C. Sanger, baggage-master, and A. D. Bentley, brakeman, were badly hurt, Sanger fatally so. The accident occurred at the foot of a mountain, where the large pushing-engine, of which J. C. Devers was engineer, hitched on a south-bound train to pull it over the mountain. The engineer of the train had detached his engine and gone over the mountain, and young Devers had come off the siding and backed the pushing-engine up to the train. Bentley and the elder Devers were on the ground making the coupling, and Sanger was in the baggage-car. Young Devers was hurled into this car, the front end of which was torn away by the explosion, and without doubt he was killed instantly. Sanger was fearfully scalded, so that he died next day. The elder Devers was considered to be fatally injured, but at last accounts he was still living. It is said that one of the sheets of the exploded boiler was known to be cracked.

(138.) — By a boiler explosion that occurred on June 21st near Louisa, twenty-five miles from Ashland, Ky., Robert Jones was instantly killed, and his father, Jacob Jones, was fatally injured. The building in which the boiler stood was completely wrecked.

(139.) — By the explosion of a boiler at Cottondale, near Pensacola, Fla., on June 22d, Mr. H. H. Ratliff was fatally injured, so that he died in a few hours. The fireman, who was also near the boiler, was dangerously injured, but it is believed that he will recover.

(140.) — On June 27th a head blew out of one of the boilers in the Wilkeson Elevator, in Buffalo, N. Y. Chief Engineer Robert Whalen was struck by a piece of iron, and was also scalded. He will recover, however. We have not learned the extent of the property damage.

(141.) — A boiler exploded on June 28th in Stevenson's mill at Cayuga, Ont. Engineer John Commer was killed instantly, and a workman named Franks was injured so badly that he died on the following day. William Stevenson, Jr., was badly scalded about the face, and Frank Lathrum was also scalded, but not so seriously. The mill was completely wrecked, and the boiler was thrown 200 feet.

On August 2d, according to the *Scientific American*, a tack dropped into a picker machine in a four-story mill in Philadelphia, causing a $70,000 fire, in the course of which two firemen were killed and seven injured by a falling floor. The tack caused a multitude of sparks to fly out of the picker, and these ignited the inflammable yarn into which they fell and started a blaze that spread through the room very quickly.

The Locomotive.

HARTFORD, AUGUST 15, 1894.

J. M. ALLEN, *Editor*. A. D. RISTEEN, *Associate Editor*.

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ACCORDING to the London *Times*, Mr. Hiram Maxim has been partially successful in his attempt to construct a practical flying machine. He and two others have traveled some 500 feet with it. It remains to be seen whether the machine possesses the necessary stability, and whether or not it satisfies the other requisites of a practical aerial vehicle.

WE have received the *Report* for 1893 of the National Boiler and General Insurance Company, limited, of Manchester, England. It contains a variety of interesting matter relating to boilers and boiler explosions. Readers of THE LOCOMOTIVE will be pleased to learn that the National Company has found the form of butt-strap joint that the Hartford Steam Boiler Inspection and Insurance Company has long advocated, to work very satisfactorily. (For details of this joint see Fig. 5 in President Allen's Cornell lecture, as reprinted in THE LOCOMOTIVE for July, 1891.) The butt-strap joint in common use in England for high-pressure Lancashire boilers has the outer and inner straps of equal width; and this makes it difficult to do a good job of calking. In the Hartford joint the outer strap is narrower than the inner one, and the calking-edge, between successive rivets, is only half as long as in the usual Lancashire butt-joint.

The Resurrection of an Old Friend.

Another scientific magazine has appeared. It is called *The New Science Review*, and, according to the title-page, it will be published quarterly. In the first number we note with interest an article by Mrs. Bloomfield Moore, entitled *A Newton of the Mind*— rather a high-sounding title, considering that the Newton referred to is none other than the celebrated John Ernst Worrell Keely, the unspeakable, imperishable, perennial Keely, of motor fame. It appears that he is at last on the high road to success. All the obstacles that have hitherto baulked him and made his life one dreary stretch of misery and ache have dissolved away; he has finally laid bare the heart of nature, so that he can stick a pin through it and preserve it for future reference.

He comes from Table Mountain, and his name is Truthful James;
He is not up to small deceit, nor any sinful games;
But he'll tell in simple language what he knows about the how
Of the going of the motor that has never gone till now.

Let us therefore sit reverently at his feet and drink in the honeyed words of wisdom as they drop from his lips. "Physicists," he says, "have been working in the wrong direction to lead them to associate with Nature's sympathetic evolutions. It is not necessary to advance further into the unexplored region of these sympathetic flows than the ninths, to become convinced that the one I denominate the dominant is the leader toward which the remaining thirds of the triune combination (of triple sympathetic streams) co-ordinate, whether it be the cerebellic, gravital, or magnetic. When we reach the luminiferous track on the ninths, in the triple subdivision, we have proof that the infinite stream, from that unexplored region where all sympathetic streams emanate, is triune in its character, having the dominant as the sympathetic leader, to which the remainder of the celestial thirds are subservient." And again, "The nearer the approach to the neutral centers, when the dissociation takes place, the greater is the latent force evolved. In molecular dissociation the instrument is set on the thirds, meeting with a rotating resistance of five thousand pounds per square inch, without any interference with the inter-molecular position. . . . To reach the atomic centers the instrument is set on the ninths dominant, the sixths harmonic, and the thirds enharmonic, having the transmittive chord *B* associated with each. At this setting the corpuscular percussion exceeds twenty-five thousand pounds per square inch. The subservience to the co-ordinate sympathy is shown in the result by a pressure exceeding fifteen thousand pounds, reaching, in this subdivision, almost as near the neutrals as instruments can carry us. The atomic and inter-atomic settings constitute the introductory conditions governing the nodal outreach as toward the etheric. . . . The region of the inaudible is reached — the introductory etheric and the first features of the invisible latent force existing in corpuscular embrace have been handled."

Bravo, Keely! Spencer doubtless had you in mind when he cried, "Witness the pomposity of sesquipedalian verbiage!" The trouble with you, Keely, is that your language is mere words — it doesn't mean a single, solitary, most microscopic thing. We don't know whether you are crazy, or what is the matter with you; but we honestly think it is time for you to call in your family doctor.

Cheap Boiler Insurance is Dangerous.

We clip the following interesting article from our bright, artistic, and ably-edited contemporary, *Cassier's Magazine*. It is well-worth reading, and should be suggestive to boiler-owners:

The danger of employing unqualified boiler inspectors was recently well exemplified in a small English town by a boiler explosion which did considerable damage to property in the immediate neighborhood of the scene of action. The boiler in question, it would seem, had gone the way that many boilers unfortunately do go, after having served nearly the full period of their usefulness, from its last place of fairly safe operation to the paint shop of a second-hand dealer, from which it emerged spick and span, ready to be sold again to some one unacquainted with its history and eager for a bargain. Paint has a wonderfully rejuvenating power over boilers as well as some other things, and with the help of an unprincipled inspector's certificate, soon had this boiler again at work, with the result, before long, of a wrecked boiler-house, damaged buildings adjoining, though, happily, no loss of life, and a bill for the owner for the costs of the usual investigation by the local authorities. The payment of the costs was exacted "as a warning to other steam-users who rely upon unqualified, incompetent inspection, because it is cheap, and afterwards plead ignorance as an excuse for their conduct."

The episode pointedly directs attention once more to the subject of cheap boiler inspection and insurance, which off and on has been condemned for many years, though evidently not with sufficient vigor to have brought about its suppression. Cheap inspection and insurance rates, in fact, seem to possess an allurement to many boiler owners which is quite surprising, when even slight consideration will show that cheap service of any kind in connection with boilers is simply not worth having. It cannot be profitable, but certainly will prove dangerous. England, more than any other country, has suffered from a multiplicity of boiler inspection and insurance companies, and with growing competition among these, and failure on the part of steam-users to properly appreciate the value of thorough and conscientious examination of their boilers, decrease in price and corresponding decrease in the reliability of the service rendered have become natural and unavoidable results. There is a price, as has often been argued, below which a guarantee of faithful inspection cannot possibly be extended without seriously affecting the financial stability of any insurance company. A close approximation to what this price is could probably be made in most cases without much difficulty, and any offer of insurance and inspection at a much lower rate should be regarded with suspicion. In the United States, if not elsewhere, the truth of this seems to have been thoroughly realized. Boiler inspection and insurance competition are there at a minimum. The work is practically all in the hands of one company, and for a long term of years has been carried on in a painstaking, thorough manner, which has demonstrated its merits beyond all question.

Hunting For Lost Manuscripts.

The recent order of the Czar to search the subterranean halls and rooms of the great Kremlin, at Moscow, for hidden treasures, has aroused interest, not only in Russia but throughout the civilized world. The prime reason for the order is the belief that in some far away cell is hidden the famous library of Ivan IV, surnamed the Terrible. Ivan IV was the Louis XI of Russia. It is known that the famous ruler devoted the little leisure left him by war and politics to collecting Greek and Latin manuscripts, and it is believed that more than eight hundred of these precious documents are concealed in some underground cavern of the palace in which he passed much of his time. Most of these manuscripts, according to Russian scholars, upon whose recommendation the Czar has acted, are unknown to the Occidental world, and may change many of the accepted Greek and Latin traditions. The result of the tour of discovery is therefore awaited with deep interest, not only by Russian savants, but by scholars all over the world.

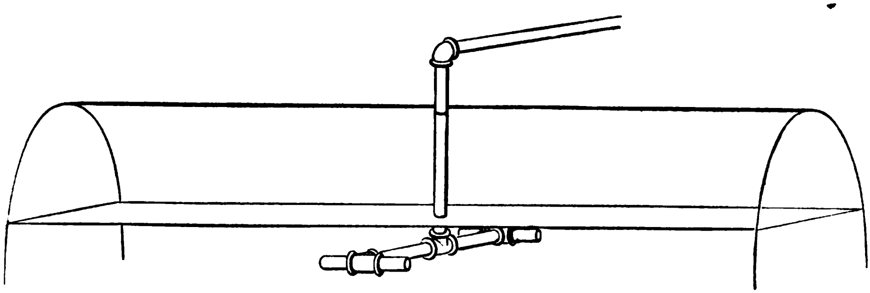
Many other things of value — intrinsic and historical — may be brought to light by the search in these caverns. The Kremlin is the most important building in all Russia. The name alone exercises even to-day a mysterious influence over every son and daughter of the golden-domed country. It is the monument of the glory — and misery — of Russia. Its history is the history of modern Russia. It has been devastated by the Tartars, it has been burned by the Poles, it has been occupied by Napoleon. It saw Peter the Great grow to manhood, it saw the fall of Boris Godounof and the False Dimitri. It has been spotted by the blood of the innocent and stained with the blood of the guilty. But with all its history, it inspires a Russian to-day with feelings to which words can give no adequate expression.

In the dark caverns are supposed to be not only manuscripts of Cicero, Cæsar, Tacitus, and the Greek writers, but documents relating to the history of Russia, testaments of ancient Russian princes, and papers left by the Mongolian Khans who once held sway within its walls. Russian writers of the seventeenth century mention the library of Ivan

IV, and say that the subterranean vaults contain other, almost countless, treasures, hidden by the Czars and princes in times of war and invasion. The only fear is that the manuscripts have been destroyed by the bookworm, the dampness natural to the depths in which they are supposed to be, or the effects of time. Weeks or even months may go by before the search is ended; but Alexander III will deserve and receive the thanks of all students for undertaking a work which Czars before him declined to do. — *New York Tribune.*

The Strains Produced by Feed-Water.

A correspondent writes as follows: "In the May issue of The Locomotive, I find an article on 'The Chilling Action of Feed-Water,' which I have read with interest. I send you some notes of a similar case which came under my notice recently, and which goes to prove the truth of the article mentioned. A manufacturer of knit-goods had in use a medium sized steel boiler, which was first-class in every respect, so far as material and workmanship were concerned. The feed-pipe was connected on the lower part of the

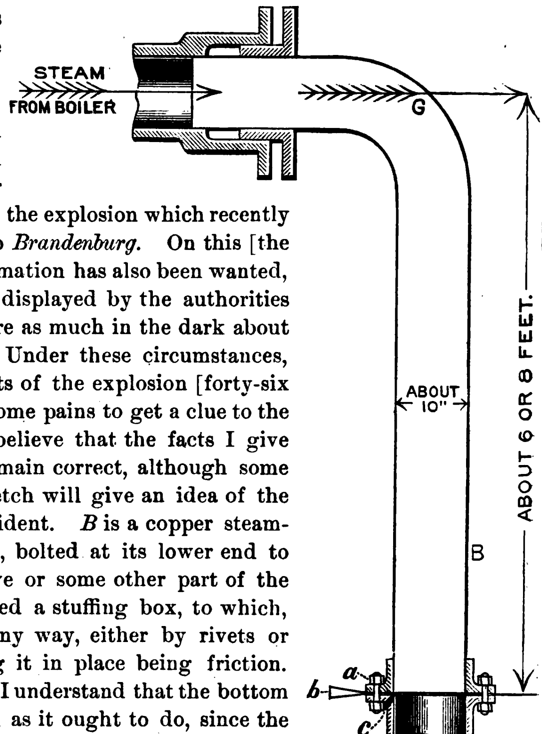


boiler, and the feed-water entered the boiler at a temperature of about 200° Fah. A leakage was discovered at the bottom of the shell where two of the plates came together, and by putting a piece on (and in other ways also) they tried to remedy the defect, but failed to do so, the shell continuing to leak in spite of every effort to stop it. An inspector was called in to look into the matter. He located the cause of the trouble and said, 'The feed-water is chilling the shell of your boiler.' Following his advice, the feed-pipe was changed so as to enter from the top, and it was then carried down till it dipped just below the water-level. Instead of allowing the pipe to discharge directly, a double L connection was attached to it, so that the feed-water was in a measure distributed to different parts of the boiler. Since this change was made, no trouble from leakage has been experienced. I send a rough sketch to illustrate the final arrangement of the feed-pipe."

Without doubt many of the leakages that occur along the girth-joints of steam-boilers are due to the chilling action of feed-water. In preparing the article cited by our correspondent, however, we had no idea of claiming to have made a new discovery. This action of feed-water has long been known, and we have called attention to it many times in the past. The article in question was intended to be merely a *popular demonstration* of the importance of locating feed-pipes correctly. Nevertheless, we thank our correspondent for his courtesy in providing us with further confirmation of it.

The Explosion on the "Brandenburg."

In the February issue of THE LOCOMOTIVE, we gave a brief account of the terrible explosion that occurred on the German cruiser *Brandenburg* on February 16th. The details of the accident were suppressed, and all particulars which might be interesting from an engineering standpoint were withheld, and the whole affair has been surrounded with mystery ever since. These circumstances have naturally led to the belief that the disaster was due to some piece of stupidity or negligence, which the German officials were ashamed to divulge. A correspondent of London *Engineering*, writing from Berlin and signing himself "An English Engineer in Germany," now gives the following particulars of the accident:



"Your correspondent '*R. N.*', whose letter of inquiry appears on page 860 of your issue of June 29th last, is not alone in his desire for information respecting the cause of the explosion which recently took place on the German warship *Brandenburg.* On this [the German] side of the Channel information has also been wanted, but so much reticence has been displayed by the authorities that German engineers generally are as much in the dark about the matter as those in England. Under these circumstances, and in view of the disastrous results of the explosion [forty-six men were killed], I have been at some pains to get a clue to the jealously guarded mystery, and I believe that the facts I give below will be found to be in the main correct, although some details may be wanting. The sketch will give an idea of the arrangement which led to the accident. *B* is a copper steam-pipe about ten inches in diameter, bolted at its lower end to the cast-iron flange of a stop valve or some other part of the engine, while its upper end entered a stuffing box, to which, however, it was not secured in any way, either by rivets or otherwise; the only force holding it in place being friction.

"When steam was gotten up, I understand that the bottom joint began to leak on the side *a*, as it ought to do, since the steam pressure, acting on the sectional area of the pipe, as indicated at *G*, had a leverage of some six or eight feet. Then, I am told, some one drove in a thin wedge at *b*, to try and stop the leak (!). The cast-iron flange next parted from its body at the black line marked *c*, and as there was then nothing to hold the pipe *B* in place, it was simply blown out of the stuffing-box, providing a free escape for the steam, with the consequences we all know. It is certainly difficult to understand how such an arrangement as I have described came to be carried out. Perhaps the publication of this letter may lead to further information being forthcoming."

There is a certain air of genuineness and truthfulness about this letter; and if the explanation here given is indeed correct, we do not wonder that the German officials strove so hard to hush the matter up. When an accident of this sort happens in America, it is the proper thing for foreigners to talk a good deal with their mouths about the flimsiness of our methods of construction.

The Development of the Sleeping Car.

In 1859 Mr. Pullman went out to Chicago to take a contract for the leveling of the streets, and the same year he hired a shop, employing a master mechanic and a number of workmen, and turned out his first sleeping car, which was run over the Chicago & Alton Railroad. It was the first sixteen-wheel car ever built, and was called the *Pioneer*. It is still preserved at the company's works in Pullman, Ill. It was larger than the ordinary coaches, and practically decided the size and form of the Pullman cars that succeeded it, only the length having been increased. Until 1864 the form of car now in use, which is as available during the daytime as at night, had never been thought of, the *Pioneer* having been built with the idea of using it only as a sleeping car. Abraham Lincoln is said to have been one of the earliest passengers on the *Pioneer*, and his body was taken from Chicago to Springfield on this car. It was so much higher than any of its predecessors it could not pass under some of the bridges. They were removed by the railroad companies, however, when the trip was made with President Lincoln's body. Later General Grant made a trip West in the car.

The *Pioneer* attracted so much attention that Mr. James F. Jay, President of the Michigan Central road, decided to try some of the cars on his line, and four were built for the purpose. They proved even more expensive than the *Pioneer*, which had cost $18,000, the average price of sleeping cars before that time having been less than a fourth of that sum. But the new cars cost $24,000 each. It was found that it would not be possible to rent a berth in one of them for the old price of $1.50, so it was decided that the berths in the new cars should cost $2. This was against the vigorous protest of the president of the road, who agreed to the advance only when Mr. Pullman suggested that the public be allowed to decide which it would patronize. So the new Pullman cars with berths at $2 each were run on trains side by side with the old-fashioned sleepers charging fifty cents less. The old cars were soon taken off the road, as nobody would use them. At present there are in use throughout the country 2,573 Pullman cars, of which 650 are buffet cars and 58 are dining cars. During 1892 the number of miles the cars traveled were 204,453,796, and 5,673,129 passengers were carried. About 9,000 meals a day are eaten in the dining and buffet cars, and 33,000,000 pieces of Pullman car linen are laundered annually.

Theodore T. Woodruff is said to have done almost as much for the improvement of the sleeping car as Pullman. Woodruff prepared his model in the office of James Tillinghast at Rome, N. Y., in 1854. Tillinghast, who was at that time in the employ of the Rome & Watertown Railroad, lacked sufficient faith in Woodruff's scheme to advance the money necessary to have it patented. Woodruff finally found a patron in a car-builder at Springfield, Mass., who built a trial car, which made its first trip on the New York Central and the Rome & Watertown Railroad. The car was afterwards run to Cleveland and other Western cities, finally becoming the property of the Ohio & Mississippi Railroad, which ran the car on its line for several years. Woodruff afterwards sold the right to build and use his cars on certain roads to Webster Wagner, and the rights of his patent on the Buffalo & Erie road were sold to George Gates. Gates operated independently until 1873, when he sold out to the Wagner Palace Car Company.

Wagner, who built all the cars for the Vanderbilt roads, was born of German parents, near Palatine Bridge, N. Y. He had learned the trade of a wagon maker as a young man. He accumulated a large fortune, and became a State Senator. He was killed on one of his cars in an accident at Spuyten Duyvil in 1882. —*New York Sun.*

On Wire Gauges.

There is hardly anything in the mechanical arts so confusing as the methods now in use by the various manufacturers for designating the sizes of wire. Almost every one of these manufacturers has his own peculiar system for numbering the wire he turns out, and the result is that "No. 24" means nothing at all unless the "gauge" is also specified. Thus, No. 24 wire is .0201" in diameter according to Brown & Sharp's gauge, .022" according to the Birmingham gauge, .023" according to Washburn & Moen, .0225" according to the Trenton Iron Company, .0231" according to G. W. Prentiss, and .025" according to the old English scale. In some other sizes, the differences are even greater. Thus, No. 000 is .3586" in diameter according to Prentiss's gauge, and .425" in diameter according to the Birmingham gauge — a difference of .0664", or more than $\frac{1}{16}$ of an inch.

To obviate this confusion, Messrs. Brown & Sharp proposed their "American Gauge," which has been adopted by the brass makers. It has also been favorably received by the principal drawers of other kinds of wire, although it has not yet been universally adopted by them. The sizes of Messrs. Brown & Sharp's scale progress in a geometrical ratio, the diameter of any size on this scale being found by multiplying the diameter of the next larger size by 0.890525. This rather clumsy ratio was chosen in order to make the new gauge agree as well as possible with the older, arbitrary gauges; for these had been in use so long that it was not likely that a new gauge would be generally adopted if it differed from the old ones radically. In the accompanying table we give the diameters of wire according to the "American gauge," and also, for comparison, the diameters of the corresponding sizes on the principal other gauges in use in this country, as quoted by Brown & Sharp.

The best way to order wire is by stating the desired diameter in decimals of an inch. This avoids all chance of misunderstanding, and assures the customer of getting what he wants. Some of the difficulties that arise from specifying the "number" of wire are thus set forth in a circular issued by Messrs. Miller, Metcalf & Parkin, and quoted by Brown & Sharp. "Another trouble is with the wearing of the gauges, for which there is no remedy; and we imagine that no man ever throws away a gauge because it is worn out. On the contrary, it represents an outlay of six dollars; he is used to it, he measures everything by it, and he is mad when anything does not measure to suit it. A still more serious difficulty arises from a very common mode of ordering. We frequently have orders for such a gauge, 'light' or 'tight', 'full' or 'scant', 'heavy' or 'easy'— terms which are perfectly ambiguous. Again, the order may be for such a number and one-half — for instance, 15½. This latter kind of order is extremely confusing to a roller, for he almost always takes it to mean that the wire is to be thicker than the whole number, and is pretty sure to make 14½ for 15½ if he is not warned beforehand. How is it possible for a roller to know just how many millionths of an inch another man, whom he never saw, means, when he says No. 28 'full', or No. 27 'easy'? And how is he to guess how many thousandths of an inch the other man's gauge is wrong in its make, or how many hundredths it has worn in years of steady use? This is no fancy sketch, for the difficulties we have referred to arise every day in this age when every man knows just what he wants and will have nothing else, and yet has no better way of telling his wants than to say he wants such a gauge 'tight', when probably his gauge differs from every other gauge that was ever made. There is a very easy and simple way out of this whole snarl, and that is to abandon fixed gauges and numbers altogether. We cannot now recall a single case of serious complaint having arisen where we have had the desired size of wire specified in decimals of an inch."

Standard Wire Gauges in Use in the United States.

(The diameters are given in decimal parts of an inch.)

Number of Wire Gauge.	American, or Brown & Sharp.	Birmingham, or Stubs'.	Washburn & Moen Mfg. Co.	Trenton Iron Co., Trenton, N. J.	G. W. Prentiss, Holyoke, Mass.	Old English, from Brass Mfrs. List.	Number of Wire Gauge.
000000	......	......	.460	......	......	......	000000
00000	......	......	.430	.450	......	......	00000
0000	.46	.454	.393	.400	......	......	0000
000	.4096	.425	.362	.360	.3586	......	000
00	.3648	.380	.331	.330	.3282	......	00
0	.3249	.340	.307	.305	.2994	.....	0
1	.2893	.300	.283	.285	.2777	......	1
2	.2576	.284	.263	.265	.2591	......	2
3	.2294	.259	.244	.245	.2401	......	3
4	.2043	.238	.225	.225	.2230	......	4
5	.1819	.220	.207	.205	.2047	......	5
6	.1620	.203	.192	.190	.1885	......	6
7	.1443	.180	.177	.175	.1758	......	7
8	.1285	.165	.162	.160	.1605	......	8
9	.1144	.148	.148	.145	.1471	......	9
10	.1019	.134	.135	.130	.1351	......	10
11	.0907	.120	.120	.1175	.1205	......	11
12	.0808	.109	.105	.105	.1065	......	12
13	.0720	.095	.092	.0925	.0928	......	13
14	.0641	.083	.080	.080	.0816	.083	14
15	.05707	.072	.072	.070	.0726	.072	15
16	.05082	.065	.063	.061	.0627	.065	16
17	.04526	.058	.054	.0525	.0546	.058	17
18	.04030	.049	.047	.045	.0478	.049	18
19	.03589	.042	.041	.040	.0411	.040	19
20	.03196	.035	.035	.035	.0351	.035	20
21	.02846	.032	.032	.031	.0321	.0315	21
22	.02535	.028	.028	.028	.0290	.0295	22
23	.02257	.025	.025	.025	.0261	.0270	23
24	.02010	.022	.023	.0225	.0231	.0250	24
25	.01790	.020	.020	.020	.0212	.0230	25
26	.01594	.018	.018	.018	.0194	.0205	26
27	.01420	.016	.017	.017	.0182	.01875	27
28	.01264	.014	.016	.016	.0170	.0165	28
29	.01126	.013	.015	.015	.0163	.0155	29
30	.01002	.012	.014	.014	.0156	.01375	30
31	.00893	.010	.0135	.013	.0146	.01225	31
32	.00795	.009	.0130	.012	.0136	.01125	32
33	.00708	.008	.0110	.011	.0130	.01025	33
34	.00630	.007	.0100	.010	.0118	.0095	34
35	.00561	.005	.0095	.0095	.0109	.0090	35
36	.00500	.004	.0090	.0090	.0100	.0075	36
37	.00445	......	.0085	.0085	.0095	.0065	37
38	.00396	......	.0080	.0080	.0090	.00575	38
39	.00353	......	.0075	.0075	.0083	.0050	39
40	.00314	......	.0070	.0070	.0078	.0045	40

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES — VOL. XV. HARTFORD, CONN., SEPTEMBER, 1894. No. 9.

The Formation of Scale in Boilers, and in Feed, Circulating, and Blow-off Pipes.

If we could run boilers with perfectly pure water — for example, with water that had previously been distilled — many of the difficulties encountered in actual practice would never arise, and the fireman's duties and responsibilities would be correspondingly lessened and simplified. Unfortunately, this ideal condition of things cannot be realized. We cannot afford to use distilled water, and in most cases feed-water has to be taken in accordance with that mode of selection which is known to the world at large as "Hobson's choice"; that is, we have to take what we can get. In cities and towns good water may usually be had from the city mains; but in sparsely populated districts the manufacturer has to depend upon wells or upon running streams, which

FIG. 1. — A FEED-PIPE NEARLY SEALED UP BY SCALE.

usually serve as sewers for the families of the employés who live along their banks. If there is organic matter in the water trouble is likely to result from corrosion and wasting of the boiler plates; and wells, which are notorious for the "hardness" of the water they furnish, are apt to provide the manufacturer with more scale-forming matter than he can comfortably handle. The water supply of cities is selected with special reference to its fitness for drinking purposes, and for this reason city water is usually comparatively free from organic matter. In most cases it consists of surface water which has not penetrated deeply into the soil, and which has, therefore, had but little opportunity of dissolving mineral matter; but in regions where lime and magnesia abound the city water is likely to be more or less charged with compounds of these substances, and under these circumstances it may be as "hard" as the general run of well waters, and may deposit a copious scale.

The reason why hard water is not good for use in boilers may be stated in a very few words. It is, that whatever may be *put into* a boiler, nothing *leaves* it by the process of evaporation but pure water, in the form of steam. Whatever solid matter may be present, either in solution or as a visible sediment, remains behind in the boiler and continues to accumulate until it is removed by the blow-off or by opening the boiler and washing it out. A steam boiler evaporates an enormous quantity of water in the course of a year, and the total amount of solid matter deposited may, therefore, be very great, even if the water contained only a few grains of it to the gallon. This fact can be well illustrated by a simple example. Thus, let us suppose a 100-horse-power boiler to be running 10 hours a day, and 300 days a year. Furthermore, let us assume that 15 pounds of water per hour are evaporated for each horse-power, and that each gallon of the feed-water contains 30 grains of solid matter in solution. Then the quantity of water evaporated in the course of a year will be

$$100 \times 15 \times 10 \times 300 = 4{,}500{,}000 \text{ pounds.}$$

As a gallon of water weighs about $8\frac{1}{3}$ pounds, this is equivalent to $4{,}500{,}000 \div 8\frac{1}{3} = 540{,}000$ gallons per year. As the solid matter present does not pass off with the steam, it must accumulate in the boiler unless it is periodically removed by blowing or otherwise. We shall assume, for the moment, that the blow-off is not opened, nor the boiler cleaned in any way, until the end of the year. Then as there are 30 grains of solid matter in each gallon of the water, the total weight of the deposit will be $540{,}000 \times 30 = 16{,}200{,}000$ grains; and as there are 7,000 grains in a pound, this is equal to $16{,}200{,}000 \div 7{,}000 = 2{,}314$ pounds, or *more than a ton of solid matter*, in the course of a year. Of course the conditions assumed in this illustration could not exist in practice, because if the boiler were not cleaned in some way, the solid matter, lodging on the plates, would protect them from the water and cause them to burn, and the boiler would be destroyed long before the end of the year. Nevertheless, we have seen many boilers containing hundreds of pounds of deposit which had accumulated in this manner, through neglect, and numerous illustrative examples from such boilers are on exhibition in the Hartford office of this company.

The great bulk of the solid matter deposited from the feed-water may be removed by frequent and judicious blowing. It cannot all be removed in this manner, however, for where the plates are hot, more or less of it is sure to bake on, forming the hard, stony layer known as "scale." The commonest components of scale are carbonate of lime ("limestone") and sulphate of lime ("gypsum"). Carbonate of lime seldom forms a stony scale. It may collect in large masses and do serious injury to the boiler, but the deposits which it forms are usually lighter and more porous than the corresponding deposits of the sulphate of lime. Most substances are more soluble in hot water than in cold; but carbonate of lime is a notable exception to this rule, for although it is somewhat soluble in cold water, in boiling water it is almost absolutely insoluble. It follows from this fact that when feed-water is pumped into a boiler, the carbonate of lime it contains is precipitated in the form of small particles as soon as the temperature of the water reaches the neighborhood of 212°. These particles are whirled about for a considerable time in the general circulation, and if the circulation is good they do not usually settle until the draft of steam is stopped for some reason — as, for instance, in shutting down at night or in banking the fires for the noon hour. The best time to remove this sediment by blowing is, therefore, just before starting up at 1 o'clock, or after the boiler has stood idle for an hour or so at night, or just before beginning work in the morning; for at these times the carbonate deposit has settled into a kind of mud at the bottom of the boiler.

Sulphate of lime differs from the carbonate in being *more* soluble in hot water than in cold; and it is, therefore, not deposited in the same way. The sulphate deposit is formed at those points where the evaporation (and consequent concentration of the solution) is most rapid — that is, in contact with the shell, the tubes, and the back head. Being deposited practically in contact with the iron, it forms a hard, adherent coating, which often resembles natural stone so closely that nobody but a skilled mineralogist could tell the difference between them. The best way to treat water containing sulphate of lime is to convert the sulphate into carbonate, and remove the carbonate thus formed by means of the blow-off, as already described. This can be done, without injury to the boiler, by the use of soda ash, which is a crude carbonate of soda.

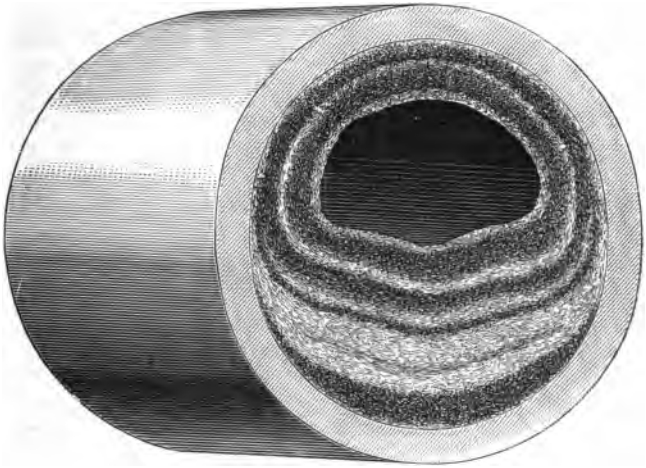


FIG. 2. — A FEED-PIPE CONTAINING A HEAVY DEPOSIT.

The chemical action that takes place may be briefly described thus: *Carbonate of soda* and *sulphate of lime* act upon each other so as to produce *sulphate of soda* and *carbonate of lime.* The sulphate of soda thus produced is what is known in commerce as Glauber's salts. It is very soluble in water, and passes away readily through the blow-off.

A great deal has been published, in the engineering journals, about scale in boilers, and yet very little has been said about the accumulation of it in feed and blow-off pipes. There are mechanical men who maintain that scale cannot accumulate in pipes in which the water is circulating constantly, or nearly so, as in the case of feed-pipes and external or internal circulating pipes; but the cases cited and illustrated in this article will show how fallacious such opinions are. As a matter of fact, these pipes often fill up in a remarkable way, the deposit choking them to such an extent that it becomes a source of positive danger. In Fig. 1, for example, we show the end of a feed-pipe which had become so choked with scale as to be practically sealed up tight. The concretion in this case consists chiefly of carbonate of lime, and, after what has been said of the properties of this substance, the way in which the state of things here shown came about will be readily understood. The feed-water, becoming heated by the steam and water in the boiler, could no longer hold its carbonate of lime in solution, and it was precipitated as described above. Most of the carbonate thus precipitated passed into the general circulation of the boiler in the usual way, but some of it adhered to the end of the feed-pipe, and the deposit thus begun continued to collect until the state of things shown in the cut was the result. This pipe is an inch and a quarter in diameter, internally, and it was stopped up by the deposit until only a small triangular hole was left, the area of which is about $\frac{1}{125}$ of a square inch.

Fig. 2 shows another feed-pipe in which the deposit was of a similar character, except that it extended back from the end of the pipe to a considerable distance. The history of this pipe is substantially the same as that of the preceding one. In each case the engineer in charge of the plant thought the difficulty was with the pumps, which could not be made to run fast enough to feed the boilers ; and in each case investigation showed that the pump was all right, and proved that the trouble lay in the feed-pipe.

The deposit in the pipe shown in Fig. 3 was of a different character. It was solid, stony, and fully as hard as granite. This pipe was originally an inch and a half in diameter internally, but it had become so filled up that the free opening at the end shown in the cut was reduced to a sort of rectangular slit an eighth of an inch wide and less than half an inch long. The sectional area of this slit is estimated to be 0.07 sq. in., and as the original sectional area of the pipe was 1.77 sq. in., it is easily seen that the effective area of discharge was reduced by the deposit to *less than one twenty-*

FIG. 3. — A FEED-PIPE CHOKED WITH A STONE-LIKE SCALE.

fifth of the area intended by the builder of the boiler.

The most troublesome form of scale is deposited in pipes that are exposed to the fire ; for in such cases the heat causes the sediment to "bake on," so that it can be removed only with a cold-chisel. Blow-off pipes are particularly liable to this trouble because there is no circulation in them, and the sediment that is sure to settle there is directly exposed to the heat of the fire. To avoid the difficulty so far as possible, the blow-cock should be opened at least once a day, and where the water is bad it should be opened three times a day, if only for a few seconds. This will keep it fairly free from deposit, and in a great measure prevent it from burning. (Coverings, or sleeves, are often fitted to blow-off pipes to protect them from the fire. See THE LOCOMOTIVE for September, 1891.) We have often called attention to the importance of using plug-cocks on blow-off pipes — or, at any rate, valves whose opening is straight, and equal to the full diameter of the blow-off pipe itself. If this precaution is neglected there is a liability of fragments of scale lodging in the pipe in front of the valve, and these may cause an accumulation of matter sufficient to stop up the pipe and allow it to burn.

We have spoken, thus far, only of feed-pipes and blow-offs ; but what we have said will of course apply to water-grates, coil heaters, and water-tube boilers generally, with a force varying according to the quality of the feed-water, the design of the apparatus, and the degree of intelligence with which it is used. For example, we have seen the four-inch tubes taken from water-tube boilers, that were almost entirely filled with a hard, sulphate scale. The deposit so formed may protect the tubes and connections from the water to such an extent as to allow of over-heating and burning, giving no end of trouble from the failure of sections and headers and other parts. As an illustration of what may happen in this way we will quote from a report recently received from one of our inspectors, concerning a certain feed-water heating device in the construction of which a number of tubes are used. The device was put in operation on August 22d, and for four months *was thoroughly blown out every six hours.* "On December 17th, the header uniting the 2″ and 4″ pipes in No. 3 boiler stripped the thread, blowing the fire, part of the grate-bars, and a few fire-brick into the room, but fortunately injuring nobody. I had the coil repaired and instructed the fireman to blow out every *four* hours. This coil had some scale in it, but it was not badly choked, *so far as it could be examined.* On December 21st the fireman reported the coil on No. 5 to be *red-hot* at the junction between the 4″ pipe and the back connection. I had the fires drawn and the coil and boiler were examined. The boiler was perfectly clean, but there was considerable scale in the pipe leading from the coil to the boiler. This was cleaned as far as possible, and the boiler was started again. On December 22d in No. 3 boiler ruptured through one of the 2″ coil pipes. We then decided to remove the coil. We had to cut the fittings to get it out, and we found the fittings and the pipes near them to be nearly filled with scale. On December 27th the coil on No. 4 boiler burst in the same way as No. 3. We then began to remove all the coils; but on December 29th No. 5 failed by breaking a fitting, and on December 31st No. 7 ruptured a pipe. At the present time [January 23d], I have had all the coils removed except that on No. 10, and have found in all that the 2″ pipes and fittings are badly choked with scale, some of them being almost completely filled. Until September we used nothing but artesian water; but since then we have used from 10% to 20% of river water." [The river water contains about 24 grains of solid matter per gallon, chiefly lime and magnesia carbonates, with some lime sulphate. The artesian water referred to averages about 10.64 grains of solid matter per gallon, mostly in the form of carbonates.] We quote this case, not because we have any special animosity towards this particular form of heater, but because it is a good illustration of the trouble that may arise from the accumulation of scale in water-tubes exposed to the action of heat.

Inspectors' Report.

JULY, 1894.

During this month our inspectors made 7,698 inspection trips, visited 15,151 boilers, inspected 8,242 both internally and externally, and subjected 630 to hydrostatic pressure. The whole number of defects reported reached 11,160, of which 1,097 were considered dangerous; 61 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,015	62
Cases of incrustation and scale,	2,214	80

Nature of Defects.	Whole Number.	Dangerous.
Cases of internal grooving,	126	9
Cases of internal corrosion,	905	20
Cases of external corrosion,	951	87
Broken and loose braces and stays,	169	39
Settings defective,	439	45
Furnaces out of shape,	495	25
Fractured plates,	262	87
Burned plates,	279	33
Blistered plates,	263	37
Cases of defective riveting,	791	44
Defective heads,	199	25
Serious leakage around tube ends,	1,293	226
Serious leakage at seams,	379	20
Defective water-gauges,	339	59
Defective blow-offs,	177	52
Cases of deficiency of water,	27	17
Safety-valves overloaded,	79	21
Safety-valves defective in construction,	100	36
Pressure-gauges defective,	532	39
Boilers without pressure-gauges,	39	39
Unclassified defects,	87	0
Total,	11,160	1,097

Boiler Explosions.

JULY, 1894.

(142.) — On July 2d a steam heater exploded in Milwaukee, Wis., and William Richardson, superintendent of the Milwaukee Mill Furnishing Company, was scalded and otherwise injured. At last accounts his condition was very critical.

(143.) — The boiler of the steamer *Queen* exploded on July 4th in North Thompson River, 12 miles north of Kamloops, B. C. The boat was blown to pieces. Fireman Joseph Rushmond and the cook, Joseph Priet, were instantly killed, and nothing could be found of their bodies. Captain Ritchie was seriously scalded, cut, and bruised, and Engineer Martin was badly hurt.

(144.) — One of the safety boilers in the Silver Spring bleachery, in Providence, R. I., exploded on July 11th. Pasco Chedsey, an Italian, was hauling ashes from the ash-pit of an adjoining boiler at the time. He was thrown some distance and badly scalded by the escaping steam. It is believed that he will recover.

(145.) — A boiler exploded on July 12th in the creamery at Crapaud, near Charlottetown, P. E. I. We did not learn further particulars.

(146.) — On July 14th a boiler exploded at the Eccleson & Parmele Lumber Association's mills, at Jacksonville, N. C. Tony McCann, Sherman Edwards, and Edward Johnson were killed instantly, and Augustus Daniels was scalded so badly that he died two days later. McCann was fireman, and the others were his assistants. The principal part of the boiler, weighing six tons, was found, after the explosion, about 1,000 feet from the mill. In its passage it felled a pine tree two feet in diameter.

(147.) — A small boiler exploded in a wagon-shop in Menommee, Wis., on July 18th, wrecking the building in which it stood. Nobody was hurt.

(148.) — One of the boilers in the Catsburg Coal Company's electric plant at Catsburg, near Monongahela, Pa., exploded on July 18th. The engineer was injured, but not dangerously so. The power-house was somewhat injured, and the property loss was probably about $6,000.

(149.) — The boiler of a threshing engine exploded near Hudson, Ohio, on July 19th. Gabriel Ously was instantly killed. Barney Morgan was fatally scalded, and Edward Carter was injured internally and cannot live. The fire-box was blown into a straw stack, which blazed up and set fire to an adjoining barn so quickly that a dozen men who were in it barely escaped with their lives.

(150.) — Considerable damage was done, on July 19th, by the explosion of a boiler used in connection with the baths in the Jewish synagogue, known as the House of Jacob, in Utica, N. Y. The boiler was situated in the basement, and the explosion tore up a considerable part of the floor in front of the chancel, together with the first three or four rows of seats, fragments of which were blown through the ceiling. Some of the windows were blown out, the chandelier was wrecked, and what had been, a few minutes before, an attractive synagogue, was transformed into a scene of wreck and ruin. Nobody was in the bath at the time, and nobody was injured save the janitor, whose feet were slightly hurt.

(151.) — The boilers in a large saw-mill belonging to White & Co., at Kendall's Station, fifteen miles west of Helena, Ark., exploded on July 19th, killing one man and fatally scalding two others. The mill was totally wrecked. One of the boilers was thrown 500 feet through the tree-tops.

(152.) — A boiler exploded on July 20th in Jachin's hat-shop, in Newark, N. J. Fire followed, and the shop and six frame tenement houses near the boiler-house were destroyed. The account says, "it is believed that several lives were lost."

(153.) — On July 21st a threshing-machine boiler exploded at Deer Creek, near Logansport, Ind. Two men were badly scalded and a third narrowly escaped being killed by pieces of flying débris. The boiler was blown into scraps, and it was considered marvelous that all the men were not killed instantly.

(154.) — On July 22d, while the steamer *Onega* was racing with the *Kindrick*, about forty miles from Chattanooga, one of the flues in her boiler collapsed. Frank Butler, who was directly in front of the boiler, was deluged with steam, boiling water, and burning coals. He cried out, "Men, I'm killed," and sprang into the river. He did not come to the surface again, and it is not known whether he died from the burns or was drowned. His body could not be found.

(155.) — The boiler of a hoisting engine exploded on July 23d at the Savannah, Florida & Western railway wharves at Savannah, Ga. The hoisting engine was blown into the air and the smoke-stack fell sixty feet away. Live coals were blown into the hold of the *Concezione*, an Italian bark with a cargo of sulphur. The sulphur took fire in two places, and was extinguished with difficulty. The engineer says that the steamer gauge registered 55 pounds at the time of the explosion. The safety-valve was set at 80 pounds.

(156.) — A big boiler exploded on July 24th in the water pumping station and electric light plant in Perry, Iowa. The power-house was literally blown to atoms, not one brick being left in its place, and the wreckage was strewn over several blocks. The water-works belonged to the city and the electric light plant to a private company, but both were in the same building. The dynamos and the city pumps were torn from their foundations and "twisted out of all semblance to their former shape." The explosion took place about 7 o'clock, while the men were at supper, and the only person about the place was Mr. H. C. Hock, manager of the Electric Light Company. Mr. Hock was fearfully injured, and will undoubtedly die. John Blougher, who was driving past the building in a buggy, was struck on the head by a brick and knocked senseless. The property loss was probably about $15,000.

(157.) — On July 24th a boiler exploded in the creamery at Harmon, near Sterling, Ill. Nobody was present at the time. The smoke-stack was blown down and the building was considerably damaged. We have seen no estimate of the property loss.

(158.) — The boiler in McNeil's mill, at Gloster, Miss., exploded on July 24th. John Anderson was killed instantly, and George Shropshire and James Blaylock were fatally scalded.

(159.) — A boiler exploded, on July 25th, at the electric plant of the Will mine, in Monongahela City, Pa. A man named Spence received injuries that will probably prove fatal. The property loss was about $6,000.

(160.) — On July 26th a boiler exploded in Yancy & Dyer's flouring mill, at New Cassel, near Fond du Lac, Wis. The mill was wrecked, and Lowell Dyer, a young man of 18, was fearfully scalded, so that he died a few hours later.

(161.) — By the explosion of a saw-mill boiler at Poplar Grove, Ind., on July 26th, William Williams was killed and two other men were injured.

(162.) — The boiler of freight engine No. 82, on the Wabash road, exploded on July 27th at Ashwood, near Defiance, Ohio. Traffic was delayed several hours. We did not learn further particulars.

(163.) — One of a battery of twenty-one boilers exploded on July 28th at Packer colliery No. 4, operated by the Lehigh Valley Coal Company, at Ashland, Pa. John Miller was killed instantly, and John Laubach, Darby Shields, and John Malingo received injuries from which they died in a short time. Steven Shelsick was also painfully injured, but he will recover. The east end of the boiler-house was blown out, the roof was considerably damaged, and one of the large smoke-stacks was knocked down.

(164.) — A slight boiler explosion occurred on July 30th in the creamery at Lyndon, Kan. The account that we received says, "things let loose, and the flues went out at the top of the boiler." The damage was small, and it does not appear that anyone was hurt.

(165.) — The boiler of a Canadian Pacific consolidation engine exploded near Field, B. C., on July 30th, while pushing a freight train up a steep grade known as "the hill." The locomotive was blown to pieces and Engineer Wheatley and Fireman Hunt were killed instantly. George Kemp, a brakeman on the rear car, was fatally injured by flying fragments of the boiler. (He died on August 1st.)

(166.) — On July 31st a boiler exploded in Atkinson's mill, at Mount Vernon, Ill. John Atkinson, the proprietor, was thrown a distance of fifty feet, and instantly killed.

Flying by Steam.

Figuratively speaking, flying machines have been in the air for some months past. More than this, some have actually flown over distances to be measured in hundreds of feet, and within the limits of their construction have been successful. But they have all been models rather than actual machines. None of those that have hitherto been described in our columns have been designed to carry a crew, or have ever been provided with motive power sufficient to keep them in action over more than short periods. But last Tuesday, July 31st, for the first time in the history of the world, a flying machine actually left the ground, fully equipped with engines, boiler, fuel, water, and a crew of three persons. Its inventor, Mr. Hiram Maxim, had the proud consciousness of feeling that he had accomplished a feat which scores of able mechanics had stated to be impossible. Unfortunately, he had scarcely time to realize his triumph before fate, which so persistently dogs the footsteps of inventors, interposed to dash his hopes. The very precautions that had been adopted to prevent accidents proved fatal to the machine, and in a moment it lay stretched on the ground, like a wounded bird with torn plumage and broken wings. Its very success was the cause of its failure; for not only did it rise, but it tore itself out of the guides placed to limit its flight, and for one short moment it was free. But the wreck of the timber rails became entangled with the sails, and brought it down at once. The machine fell on the soft sward, embedding its wheels deeply in the grass, and testifying, beyond contradiction, that it had fallen and not run to its position. If it had not been in actual flight, the small flanged wheels would have cut deep tracks in the yielding earth. . . . The propelling power is derived from two screws 17 ft. 6 in. in diameter, revolving at 400 revolutions per minute, and giving a total thrust of 2,000 pounds. Each screw is driven by a compound engine, both engines drawing their steam from a tubular boiler of most ingenious construction. The weight of the boiler, complete, with 200 lbs. of water, is only 1,200 lbs., and yet Mr. Maxim contrives to get 300 horse-power out of it. The fuel is gasoline, which is gasified and burned as a gas from several thousand jets, and the whole arrangement is so sensitive that the steam pressure can be raised 100 lbs. in a minute if required. At every point in his design Mr. Maxim has been obliged to leave the beaten track of mechanics and find new paths. Indeed, the machine constitutes a perfect museum of inventions, and would repay hours of study. . . . The boiler, with its accessories, is mounted on the deck of the machine. The engines are carried by the framing, several feet higher, in order that the screws may be well elevated. Over all comes the great aëroplane of 1,400 square feet area, designed to glide over the surface of the air, and to carry the major part of the weight. From each side of this great aëroplane, which is 50 feet wide, stretches a wing extending 38 feet further, making the entire stretch from side to side 126 feet. Two other wings, of about equal size, extend outward a few feet from the ground, and, if need be, three other pairs can be interposed between the upper and lower wings. These are all carried by a framing of steel tubes and wires, and are stiffened by hollow timber struts which are marvels of workmanship. These wings and aëroplanes are all fixed, and have no motion relative to the machine. The steering, in a vertical direction, is done by a pair of horizontal planes, arranged one forward and one aft. These are pivoted and connected by wire ropes to a steering wheel on deck, by which they can be simultaneously tilted to cause the machine to soar or to descend. Steering sidewise can be effected, as in a ship, by varying the speed of the screws.— *Engineering* (London).

The Locomotive.

HARTFORD, SEPTEMBER 15, 1894.

J. M. ALLEN, *Editor*. A. D. RISTEEN, *Associate Editor*.

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WE desire to acknowledge the *Report* for 1893 of the Hannover Verein zur Ueberwachung der Dampfkesseln, and also that of the Milan Associazione fra gli Utenti di Caldaie a Vapore.

MR. HENRY ADAMS of Baltimore, Md., kindly sends us the following correction: "I notice in your July issue an error in the brief article on *Congressional Ventilation.* You mention that sixteen fans are used for the House of Representatives. There are only six employed, and of these four are practically of no use." We thank Mr. Adams for the correction, which we make with pleasure. As stated in the article in question, our information was obtained from the daily press.

Professor Helmholtz.

Professor Hermann Ludwig Ferdinand von Helmholtz, the celebrated German physicist and physiologist, died in Berlin, on September 8th, of paralysis. Professor Helmholtz was born in Potsdam, Prussia, on August 31, 1821, and was graduated as a physician from the royal military school in Berlin at the age of 21. His first great contribution to science was his classical memoir on *The Conservation of Energy*, which appeared in 1847, and which alone would have been sufficient to ensure him a lasting fame. In 1858 he published his remarkable mathematical researches on the motion of vortices ("smoke rings"), which were of especial interest on account of their bearing on a certain theory of the ultimate structure of matter, called the "vortex theory," and due, we believe, to Lord Kelvin. In 1862 he gave to the world his marvelous book on *Sensations of Tone, as a Physiological Basis for the Theory of Music*, which was followed, five years later, by the *Manual of Physiological Optics.* Throughout his long life he was ardently devoted to science, and paid little or no attention to politics or other matters outside his own line of work. He had a fine face and a fine figure, and was very popular among his students and among the German people generally. He received the Copley medal of the Royal Society of London in 1873, and in 1883 he was "ennobled" (if an official act of a king could ennoble such a man) by Emperor William I, in recognition of his important contributions to science. He attended the World's Fair in 1893, and while in New York he spoke before the College of Physicians and Surgeons on the ophthalmoscope, of which instrument he was the inventor.

Thin Films of Gold.

In the July issue of THE LOCOMOTIVE (page 116) we referred to the extremely thin films of gold recently produced by Mr. J. W. Swan. We learn, from the September issue of the *Journal of the Franklin Institute*, that Mr. J. B. Outerbridge made use of the same process, in this country, as long ago as 1877. "One of the interesting exhibits made at the recent *conversazione* of the Royal Society, held June 13, 1894," says the *Journal*, "was that of Mr. J. W. Swan, F.R.S., who presented a number of specimens of leaves of gold of extreme thinness, which had been prepared by the process of electro-deposition. From a brief notice of the exhibit, published in London *Nature*, it appears that it represented an attempt by Mr. Swan, to produce gold leaf by electro-chemical, instead of mechanical means. 'The leaves were prepared by depositing a thin film of gold on a highly polished and extremely thin electro-copper deposit. The copper was then dissolved by perchloride of iron, leaving the gold in a very attenuated condition. The leaves were approximately four one-millionths of an inch thick, and some of them mounted on glass showed the transparency of gold very perfectly when a lighted lamp was looked at through them.' It will doubtless prove somewhat of a surprise to Mr. Swan to learn that identically the same method of procedure for the production of films of metal of extreme tenuity was described and illustrated by Mr. A. E. Outerbridge, Jr., in a lecture delivered before the Franklin Institute in 1877, an abstract of which was published in the *Journal*.* At the stated meeting of the Institute held May 16, 1877, the then resident secretary, the late Mr. J. B. Knight, made reference in his monthly report to the thin gold films produced by Mr. Outerbridge in the following terms:†

"'In the course of a lecture on gold, delivered before the Franklin Institute, on February 27th last, Mr. A. E. Outerbridge, Jr., of the Assay Department of the Mint in this city [Philadelphia], gave an account of some experiments he had made, with the view of ascertaining how thin a film of gold was necessary to produce a fine gold color. The plan adopted was as follows: From a sheet of copper rolled down to a thickness of $\frac{5}{1000}$ of an inch, he cut a strip $2\frac{1}{2} \times 4$ inches. This strip, containing 20 square inches of surface, after being carefully cleaned and burnished, was weighed on a delicate assay balance. Sufficient gold to produce a fine gold color was then deposited on it by means of the battery; the strip was then dried without rubbing, and re-weighed, and found to have gained $\frac{1}{10}$ of a grain, thus showing that one grain of gold can, by this method, be made to cover 200 square inches, as compared with 75 square inches by beating. By calculation, based on the weight of a cubic inch of pure gold, the thickness of the deposited film was ascertained to be $\frac{1}{980400}$ of an inch, as against $\frac{1}{367650}$ for the beaten film. An examination under the microscope showed the film to be continuous and not deposited in spots, the whole surface presenting the appearance of pure gold. Not being satisfied, however, with this proof, and desiring to examine the film by transmitted light, Mr. Outerbridge has since tried several methods for separating the film from the copper, and the following one has proved entirely successful. The gold plating was removed from one side of the copper strip, and by immersing small pieces in weak nitric acid for several days, the copper was entirely dissolved, leaving the films of gold, intact, floating on the surface of the liquid. These were collected on strips of glass, to which they adhered on drying, and the image of one of them is here projected on the screen, by means of the gas microscope. You will observe that it is entirely continuous, of the characteristic bright green color,

* *J. F. I.*, ciii, 284.

† *J. F. I.*, ciii, 369.

and very transparent, as is shown by placing this slide of diatoms behind the film. By changing the position of the instrument, and throwing the image of the film on the screen by means of a reflected light, as is here done, you will see its true gold color. Mr. Outerbridge has continued his experiments, and, by the same processes, has succeeded in producing continuous films, which he determined to be only the $\frac{1}{2798000}$ of an inch in thickness, or one 10,584th the thickness of an ordinary sheet of printing-paper, or only one 60th the length of a single undulation of green light. The weight of gold covering 20 square inches is, in this case, $\frac{35}{1000}$ of a grain, one grain being sufficient to cover nearly 4 square feet of copper. As you see, the film is perfectly transparent and continuous, even in thickness, and presents all the characteristics of the one shown before. That a portion of the image appears darker is due to superposed films, the intensity of the green color being proportional to the thickness through which the light passes.'

"It may be stated, in conclusion, that the mode of procedure above described was patented by its author* under the title 'Manufacture of Metallic Leaf.' In his patent the inventor describes, as 'a new and improved method of manufacturing gold leaf, silver leaf, and other metallic leaf,' the above-named method of electrical deposition. As suitable mediums to support his films, he mentions copper in thin sheets, and paper, shellac, wax, etc., made conductive upon the surface which is to receive the deposit. For removing the deposited film from copper and paper, Mr. Outerbridge describes the use of a bath of dilute nitric acid, or of perchloride of iron. In the case of the shellac, wax, etc., alcohol, benzine, and other solvents are referred to.

"While these circumstances detract neither from the interest nor the genuineness of Mr. Swan's work, they are recalled in this place in justice to Mr. Outerbridge, to whom priority is undoubtedly due."

Measuring Cards with the Planimeter.

We have received numerous inquiries, recently, about the use of the planimeter in measuring indicator cards. The usual question that we are asked is, Why must one divide the area of the card by its length? The present article is intended as an answer to this question.

In the first place it is important to remember *what an indicator card is*. It is nothing more nor less than a record of the pressures that existed in the cylinder at every part of the revolution during which the card was taken. The length of the card represents the stroke of the engine, and the height of any point in the card, measured from the atmospheric line, represents the pressure that existed in the cylinder when the indicator pencil was passing that point. The *scale* on which the pressures are recorded depends upon the stiffness of the spring that was used. The springs that are supplied with indicators are always stamped with numbers that show what the corresponding scale of the card is. For example, if the number "40" is stamped on a particular spring, the maker of the instrument intended the pencil to rise one inch for every 40 pounds pressure when this spring is used. To illustrate this point further, let us refer to Fig. 1, which represents an indicator card taken with a "50" spring. If we wished to know the pressure in the cylinder when the piston has traveled three-quarters of the forward stroke, we proceed as follows: Three-quarters of the way from *A* to *B* we draw the vertical line *ab*. Upon measuring the length of *ab* we find it to be (say) $\frac{5}{16}$ of an inch. Then the pressure in

* U. S. Patent, 198,209, December 18, 1877.

the cylinder when the piston had traveled three-quarters of the stroke was $\frac{5}{16} \times 50 = 15\frac{5}{8}$ pounds per square inch. To find the pressure in this end of the cylinder (*i. e.* the "back pressure") when the piston has traveled say $\frac{5}{8}$ of the return stroke, we proceed in a similar manner, drawing the line *cd*, $\frac{5}{8}$ of the way from *B* to *A*, and measuring it.

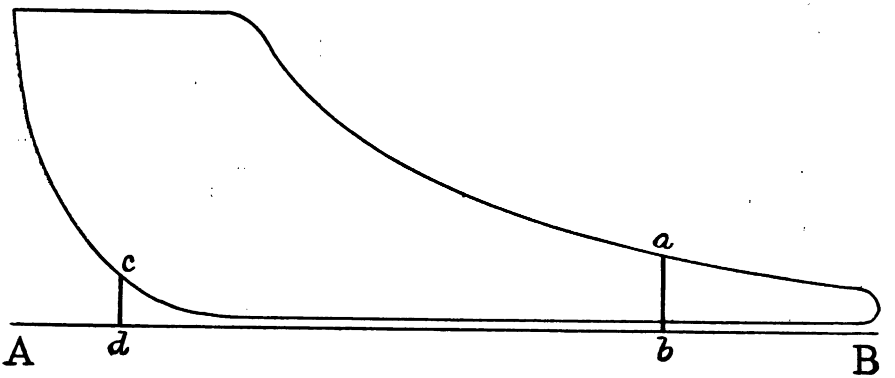

FIG. 1. — TO FIND THE PRESSURE AT ANY POINT IN THE STROKE.

Suppose we found the length of *cd* to be $\frac{5}{32}$ of an inch. Then the back-pressure at this point in the stroke was $\frac{5}{32} \times 50 = 7\frac{13}{16}$ pounds per square inch.

What we want, in calculating the horse-power of the engine, is the *average pressure* in the cylinder. We can get this closely enough for most purposes by the method shown in Fig. 2. In applying this method the card is first divided up into ten equal spaces, as shown by the heavy vertical lines. These lines may be spaced by a pair of

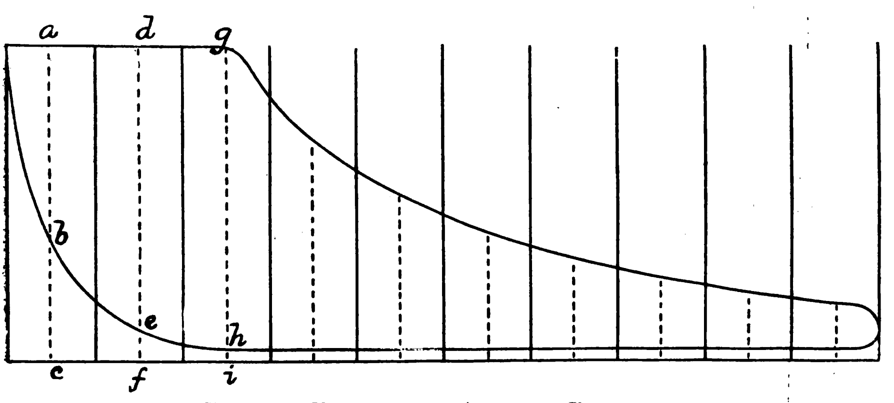

FIG. 2. — FINDING THE AVERAGE PRESSURE.

good dividers, but the easiest way to draw them is by means of the "gridiron" shown in Fig. 3, which can be had of all dealers in indicators.

The method of using the gridiron will be readily understood from the cut. When the card has been divided up by either of these methods, into ten equal spaces, we proceed to measure the height of each one of these spaces, as shown by the dotted lines *ac*, *df*, *gi*, etc.; *ac* representing the average pressure during the first tenth of the stroke, *df* the average pressrue during the second tenth, and so on. The average of all these lines will then give the *average pressure during the forward stroke.* The back-pressure, or pressure during the return-stroke, is found in the same way, by averaging the lines *bc*, *ef*, *hi*, etc. The average "effective pressure" (that is, the pressure useful in driving the engine) is then found by subtracting the average back-pressure from the average pressure during the forward stroke.

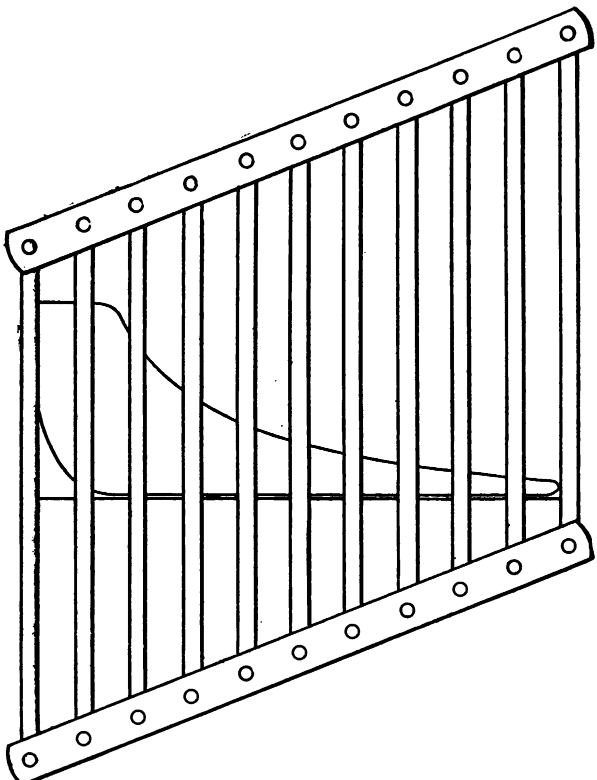

FIG. 3. — THE USE OF THE GRIDIRON.

It is easily seen that this long operation can be very much simplified by merely taking the average of the lines *ab*, *de*, *gh*, etc.; for this must give the same result as measuring the whole line and afterwards taking away the lower part. Now the average of the lines *ab*, *de*, *gh*, etc.; is nothing more or less than the average width of the card, as will be apparent upon referring to Fig. 4, which is the same as Fig. 2, except that the lower lines have been left out for greater clearness. We have therefore arrived at the following important fact: The average effective pressure in one end of the cylinder of an engine is represented by the *average width* of the card taken from that end; and this average effective pressure can be found, expressed in pounds per square inch, by

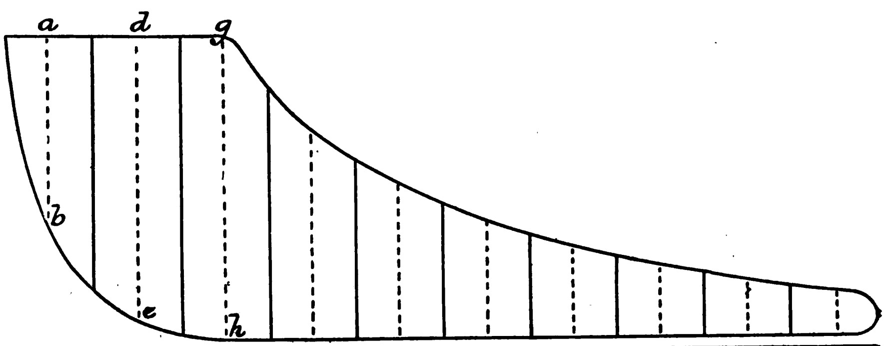

FIG. 4. — FINDING THE AVERAGE PRESSURE.

multiplying the average width of the card, in inches, by the number of the spring that was used in taking the card.

The only reason why we use a planimeter, in figuring up engine cards, is that that instrument gives us an accurate and extremely simple method of *finding the average width* of the card. It enables us to do away with the gridiron and the dividers and the vertical lines, altogether. To understand how this is, let us reflect that we could find the *area* of the card, if we wished to do so, by merely multiplying the *length* of the card by its average *width*. On the other hand, if we knew what the area was, we could find the average width by dividing the given area by the length. Now the planimeter enables us to find the *area* of the card without the least calculation; and for this reason it is much easier to find the *average width* by *dividing this area by the length of the card*, than it is to determine the average width by direct measurement of the lines in Fig. 4.

This is the whole story, except that we have not told *why* the planimeter gives the area of the card; but, as Mr. Rudyard Kipling would say, that part of it really "belongs to *another* story" — a much more difficult one to tell, too. Many proofs of the working of the wonderful little instrument have been given, and yet we fancy that no thoughtful man ever works with it without feeling that there is something almost "spook-like" about it.

The Speed of Vessels.

Lloyd's latest publication shows that out of the 13,000 steamers recorded in the "Registry," only 45 vessels have a speed of 19 knots and above, and of this number 18 are credited with a speed of 20 knots or over. Of the former number, 25, or more than half, were built on the Clyde, while of the 20-knot boats 12 are Clyde built, 3 have been constructed in other parts of the kingdom, leaving 3 for abroad. Foreign builders constructed a dozen of the 45 of 19 knots and over, but, on the other hand, foreigners own 20 of these 45. The remarkable fact is that of the 20-knot boats 9 are paddle steamers and 9 twin-screw, none being single-screw. For high speeds, therefore, the single-screw is of the past; and it might also be said that the side-paddles are giving place to twin-screw propulsion. The difficulty hitherto has been the draught of water available, the paddle requiring less water in which to work than the screw propeller, which must be completely immersed. But when it is remembered that in action the screw propeller is similar to a wheel revolving, it will be understood that by increasing the revolutions it is possible to reduce the diameter and still get the same speed. Improved types of engines make this higher number of revolutions possible, but at the same time more careful work in construction is required. A few years ago 90 revolutions was high; now 200 is exceeded in several vessels, and 400 has been reached in torpedo craft. Another circumstance which makes the screw preferable is that it has, as a rule, only half the slip of the side-paddles. Slip is used in the same sense as in the case of a locomotive wheel. The slip of a 20-knot paddle-steamer is 26 to 30 per cent. the forward motion, against 13 to 15 per cent. in a twin-screw steamer. Again, the proportion of weight of machinery to the total weight of the steamer is less in a screw steamer, since more has been done to lighten the parts than with the paddle-engine. In the latter 8½ I.H.P. has been got per ton weight, in the former 11 I.H.P. per ton. In a paddle-steamer 45 per cent. of the total weight goes in engines; in a screw-steamer, where more provision is made for cargo, only 31 per cent. of the total is for machinery. — *Glasgow Herald.*

The Locomotive.

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Concerning Blow-off Pipes.

In the September issue of THE LOCOMOTIVE, in speaking of the deposit of sediment and the formation of scale in pipes, we referred to the use of straight-way valves on blow-offs, and stated that the opening in such valves should be fully equal to the sectional area of the blow-off pipe itself. As the importance of this point is not always

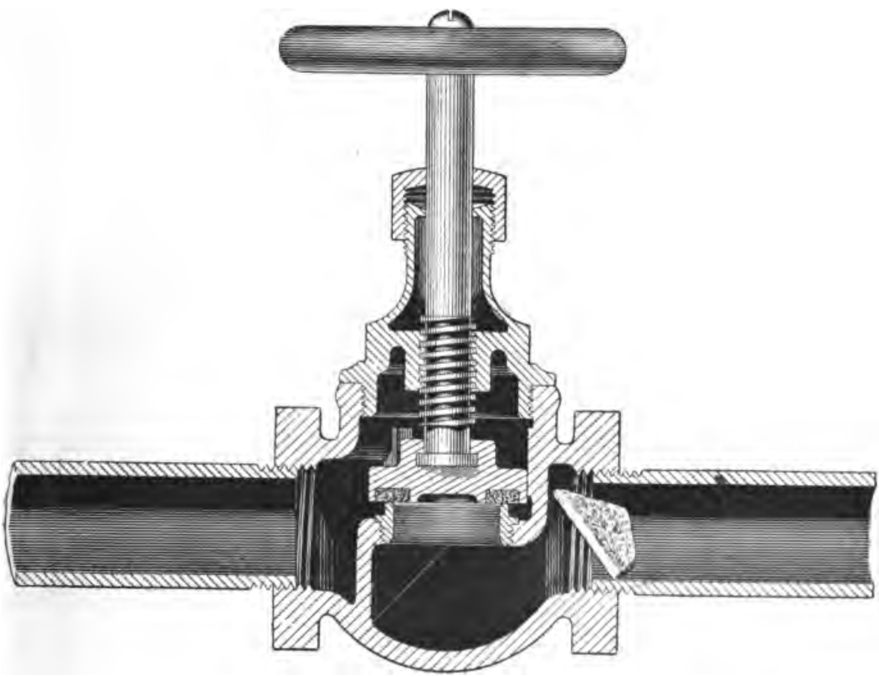


FIG. 1. — A GLOBE VALVE APPLIED TO A BLOW-OFF PIPE.

thoroughly appreciated, we herewith present two cuts (Figs. 1 and 2) which will suffice, it is hoped, to make the matter clear. Fig. 1 represents a globe valve as applied to a blow-off pipe, and we have endeavored to illustrate the fact that such a valve is liable to trap pieces of scale that have flaked off from the shell (or tubes) of the boiler. The same action may take place with any other form of valve in which the passage is not straight, or which has an opening of less area than the blow-off pipe itself. Fig. 2 illustrates a straight-way valve having an opening a trifle greater than the area of the pipe, and it will be evident, at once, that in such a valve there is far less chance for scale to lodge. It is important, however, even with straight-way, full-area valves, to open the valve wide when the boiler is blown, so that the full area may be *realized.* If, for example, the form shown in Fig. 2 be opened only a little, there is an excellent chance for fragments of scale to lodge against the plug, and such fragments may become so compacted together that when the valve *is* thrown wide open at some subse-

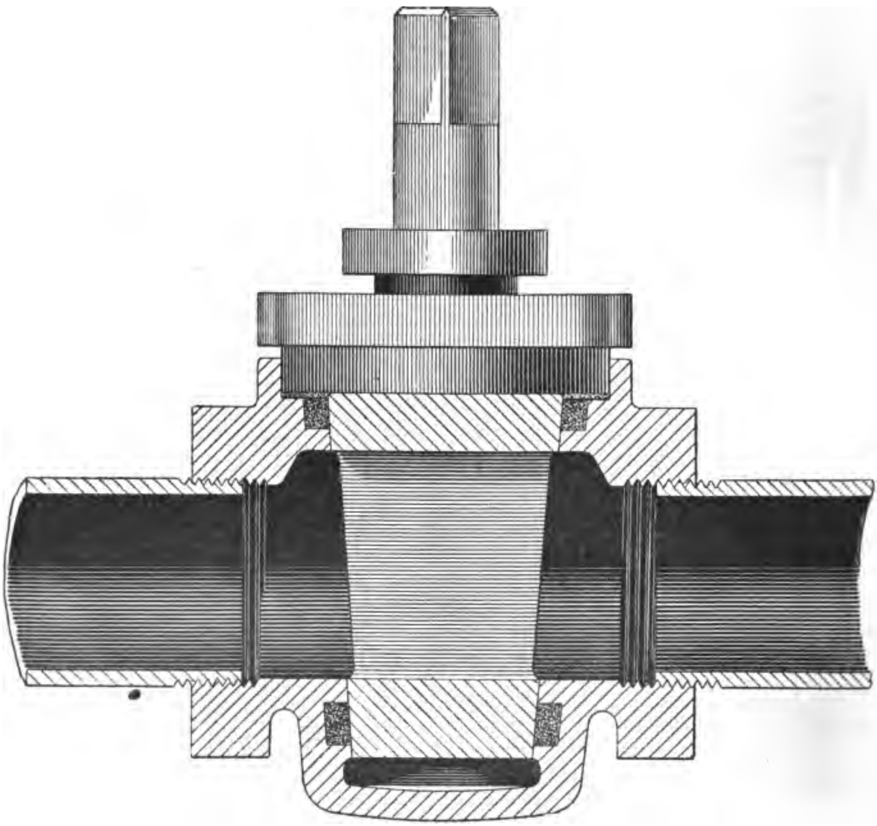


FIG. 2 — A PLUG COCK ON A BLOW-OFF PIPE.

quent time, the full boiler pressure may not suffice to blow the impediment out, and the result is likely to be the more or less complete filling up of the pipe, and its subsequent overheating and rupture. Even when the valve is to be opened only for a few seconds, it should be opened *wide.* It is by no means uncommon to reduce the size of the blow-off somewhat, after it leaves the boiler. This should never be done, for where the reduction occurs there is the same chance for the accumulation of scale that there is in a valve having a diminished area, and the same unpleasant and perhaps disastrous consequences may follow.

Although we consider the straight-way, full opening valve to be superior, for use on blow-off pipes, to globe valves or other forms that have tortuous or contracted passages, they must be used with judgment or they are liable to cause trouble of another kind, which we proceed to explain. To take a concrete example, let us consider a boiler carrying 80 pounds of steam, and let us suppose that the blow-off valve is opened wide. Then it is easy to show, by the principles of hydrodynamics, that, if friction be disregarded, the water that escapes through the blow-off will have a velocity of about 109 feet per second. Now, while the column of water in the pipe is moving with this velocity, let us suppose that the plug cock is *suddenly closed.* The very considerable momentum of the mass of moving water in the pipe is bound to make itself felt, and

FIG. 3. — ILLUSTRATING THE "WATER RAM" IN BLOW-OFF PIPES.

the energy of this mass of water, due to its velocity of 109 feet per second, is expended upon the pipe and its fittings, in producing strains in the material of which they are composed. That this action is well worth serious attention is easily made apparent by considering the appliance known as the hydraulic ram. The hydraulic ram is a device for raising water by means of the very momentum we are considering. Water is allowed to flow through a "waste-pipe" until it acquires a considerable velocity, and the waste-pipe is then suddenly closed by an automatic clack-valve. The pressure in

FIG. 4. — ILLUSTRATING THE "WATER RAM" IN BLOW-OFF PIPES.

the waste-pipe at once increases greatly, owing to the momentum the water has acquired, so that a part of the water escapes through a check-valve, into a delivery pipe connected with a reservoir considerably higher than the level of the pond from which the main supply is taken. By properly designing such a ram, it is found to be possible, in actual practice, to make the resulting momentum-pressure exceed the static pressure due to the normal head of water in the waste-pipe, by *twenty fold* — the practicable delivery-head of the ram being 20 times the supply-head. If this same increase in pressure could be realized in the case we are considering, the pressure in the blow-off pipe would rise to $20 \times 80 = 1,600$ pounds per square inch, when the valve is *suddenly closed.* We do not affirm that such an extraordinary excess of pressure as this does occur in blow-off pipes, and yet we believe that this computation will satisfy the reader that it is not a good plan to trifle with plug-cocks in any such way as we have described, and that the danger we have suggested is not imaginary, but real, and worthy of serious consideration. What the actual increase in pressure in blow-off pipes, from this cause, may be, we cannot say ; but we do know that accidents frequently occur, in connection with such pipes, which appear to be unmistakably due to the ram-like action that we have just described. All trouble of this kind can be avoided by always closing the valve *slowly*.

The effects of the sudden rise in pressure that occurs in a blow-off pipe when the valve is closed too quickly are naturally felt most in the fittings, which are almost invariably made of cast-iron. This is indicated by the arrows in Figs. 3 and 4, which illustrate two common ways of putting in blow-off pipes. The elbow is liable to break, or the valve itself may fail, or the pipe may burst, or the threads on the pipe or the fittings may strip (though this last-mentioned mode of failure is not so common as the others). We have also seen pieces knocked out of an elbow, or a valve, from this cause, while the greater part of the fitting still remained intact. The pipe or the fittings may withstand the rough usage that they often get, for a considerable time, and yet each shock leaves its impress on the material, and some day the blow-off fails somewhere, and somebody is burned and scalded. At such a time the front of the boiler may be an even more dangerous place than the rear, for the fire-doors are usually blown open, and the fire is blown out into the room, together with great volumes of steam and boiling water. Fig. 5 represents a fragment of a blow-off fitting that was broken in an accident of this kind that recently came to our notice.

Fig. 5. — A Broken Fitting.

Feed-pipes are often made of brass, as this material is not apt to be destroyed by pitting (unless there is some corrosive substance present in the water), and, moreover, brass pipes give the boiler-room a neat and attractive appearance. For these reasons, boiler owners are not unfrequently led to use brass for blow-off pipes also, not realizing that the conditions to which blow-off pipes are commonly exposed are radically different from those pertaining to feed-pipes. There is no objection to the use of brass in connection with locomotive, vertical-tubular, and other types of *internally* fired boilers, for in these cases the blow-off is not exposed to the fire, and brass proves to be efficient and durable. The nature of brass, however, is such that the metal will become soft, and lose its strength, at temperatures that do not injure iron. It seems to be the fact, too, that *all* alloys deteriorate when exposed to moderately high temperatures for a sufficient length of time. Safety-plugs, when filled with alloys, often become so modified by long exposure to heat that their contents will not melt out until the temperature greatly exceeds what was originally intended to be the melting point of the alloy; and it is on this account, largely, that we recommend pure tin for the filling. When a blow-off pipe is directly exposed to the heat from the fire (as it is in horizontal tubular boilers) steam must be generated in it, to some extent, and the film of steam next to the metal, by preventing the contact of water, may allow the pipe to be heated to such a temperature that the brass will become burned, or will at least soften. Such sediment as may adhere to the inside of the pipe also contributes to the same end. As the result of these various causes — that is, deterioration of the alloy when exposed to heat, the softening, and the loss of tensile strength due to the high temperature, etc.,—it often happens that brass blow-offs burst, doing considerable damage, and subjecting the owner of the plant to annoying delays until the boiler can be put in use again. Fig. 6, which represents a brass blow-off that burst recently in this neighborhood, shows what may be expected, in the course of time, from such a pipe when exposed to the heat of the fire. This pipe burst one Monday morning, while the steam pressure was 80 pounds per square inch. The rear door of the setting happened to be braced in position by a bar of iron, but the furnace doors were blown open, and the engineer was badly burned and scalded. The pipe was $\frac{3}{16}$ inch thick. Sleeves of cast-iron or other material are often provided for the protection of blow-off pipes,* and while these are certainly advantageous, they can

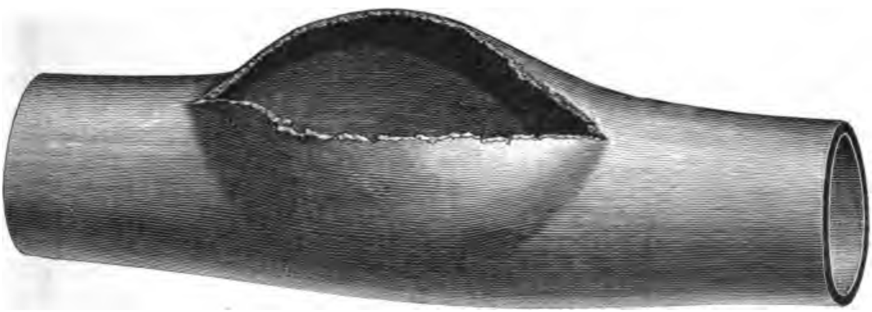


Fig. 6. — A Ruptured Brass Blow-off Pipe.

never make a brass blow-off, on an externally fired horizontal tubular boiler, as satisfactory as one constructed of good, extra heavy, iron steam pipe.

Brass and copper blow-off pipes are open to another objection, which is illustrated in Fig. 7. The pipe here represented is of brass, and it was originally $\frac{5}{32}$ of an inch thick. The part *BC* was protected by the rear wall of the setting, while *AB* was exposed to the heat of the fire. The pipe wasted away, externally, along the part *AB*, until its thickness was reduced, in places, to less than $\frac{1}{32}$ of an inch. (This is shown on an exaggerated scale in the cut. In the actual pipe, now in this office, from *A* to *B*

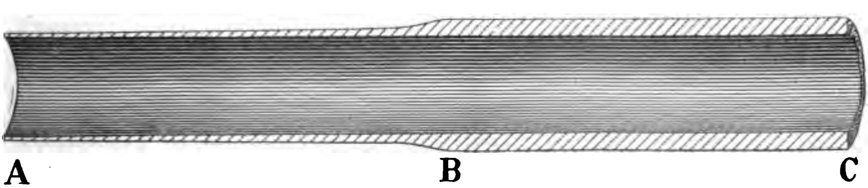


Fig. 7. — A Brass Blow-off Pipe, Wasted Away Externally.

is 26 inches, and from *B* to *C* 21 inches. The pipe is 2 inches in diameter, internally.) The reduction in thickness was uniform all around the pipe, and the effect was very much the same as would be observed if the pipe had been placed in a lathe and gradually worn away by the application of emery cloth. For some reason or other it did not burst, but held together until the boiler was temporarily put out of use, when its condition was discovered. This phenomenon, which is not perfectly understood, is by no

* See The Locomotive for September, 1891.

means uncommon where brass and copper are used for blow-offs. In a nest of three boilers, recently inspected by this company, all the blow-offs (which were copper) were found to be in a condition precisely similar to that shown in Fig. 7. It is believed that the loss of material from the outside of such pipes is due, to some extent at least, to the grinding action of small particles of unconsumed solid matter that are carried along by the draft, the action being analogous to that of a sand-blast. The objections to this theory are, first, that in such a case one would naturally expect the wear to be most rapid along the bottom of the pipe, where the particles strike it most directly; the fact being, however, that the pipe wastes away about equally, all around its circumference. The second objection to the sand-blast theory is, that although, judging from the general properties of the materials, one would expect iron pipes to wear away from attrition even faster than brass ones, the fact is, that iron blow-off pipes exhibit the phenomenon to a barely perceptible extent, if at all. We are therefore impelled to the conclusion that the wasting away of the brass and copper pipes is to be attributed, to some extent, to chemical action. It is not unlikely that some of the products distilled off from the fire may act corrosively on copper and brass, while leaving iron comparatively unaffected. However this may be, the important thing to note is, that *the phenomenon occurs;* and hence, whatever its cause may be, it is a source of danger to be borne in mind and to be provided against. And the easiest way to provide against it is to put in an *iron* blow-off pipe.

Inspectors' Report.

AUGUST, 1894.

During this month our inspectors made 7,325 inspection trips, visited 14,730 boilers, inspected 6,309 both internally and externally, and subjected 656 to hydrostatic pressure. The whole number of defects reported reached 10,757, of which 1,261 were considered dangerous; 31 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	739	35
Cases of incrustation and scale,	1,824	93
Cases of internal grooving,	114	10
Cases of internal corrosion,	745	30
Cases of external corrosion,	661	24
Broken and loose braces and stays,	117	29
Settings defective,	430	39
Furnaces out of shape,	397	15
Fractured plates,	224	35
Burned plates,	213	13
Blistered plates,	265	17
Cases of defective riveting,	1,427	134
Defective heads,	86	17
Serious leakage around tube ends,	1,753	485
Serious leakage at seams,	448	33
Defective water-gauges,	399	67
Defective blow-offs,	175	53
Cases of deficiency of water,	19	6
Safety-valves overloaded,	70	40
Safety-valves defective in construction,	108	40
Pressure-gauges defective,	475	41
Boilers without pressure-gauges,	5	5
Unclassified defects,	63	0
Total,	10,757	1,261

Boiler Explosions.

August, 1894.

(167.) — By the explosion of a boiler in the St. Joseph Valley Paper Company's mill at Elkhart, Ind., on August 1st, James Hiatt, the fireman, was seriously injured, and the building was considerably damaged.

(168.) — On August 2d, a boiler exploded at the Wheeling Steel Works, in Benwood, near Wheeling, W. Va. During the remodeling of the steel works recently, many new boilers were placed in the plant, but several of the old ones were left, the company thinking that they could be used for a time. It was one of these that exploded. The explosion could not have occurred at a more fortunate time, as the men were just changing turns. The day turn had just left its work and the night one was coming on. This is probably the reason that no lives were lost. Only a few minutes before the accident the fireman had fired the boiler that exploded, and he was at work on the next battery when the crash came. Pieces of the boiler were thrown through the iron roof, and far beyond the mill.

(169.) — A boiler exploded on August 2d in Edward Elliott's mill in Wamsley, Ohio, killing the proprietor and his brother, Charles Elliott, and injuring several employes.

(170.) — On August 2d a threshing-machine boiler exploded on a farm two miles east of Dahlgren, Ill. John Miller, engineer, and two boys, sons of John Underwood, were killed outright, and William Cremeens and Elmer Hook were fatally injured. Four other men also received injuries.

(171.) — By the explosion of a saw-mill boiler, ten miles west of Milan, Mo., on August 3d, John West, engineer, was killed, and two men named Scott and another whose name is West were scalded so badly that they cannot possibly recover.

(172.) — On August 4th the boiler of Frank Vesseli's threshing machine exploded at Montgomery, Minn. As the explosion occurred at lunch time nobody was killed, but seven stacks of wheat and the separator were burned.

(173.) — A small heating boiler exploded in Reading, Pa., on August 4th, doing some damage, but fortunately injuring nobody.

(174.) — On August 4th, while Ira Palen was threshing at the farm of John Franklin, near Jackson, Mich., the boiler of his machine exploded, scattering fire in all directions. The barn, wagon, sheds, tools, hay, and grain, and three horses were burned. The fire spread so rapidly that the men on the straw stack could get down only by rushing through the flames. Mr. Franklin was struck by pieces of the boiler and badly injured about the legs and side.

(175.) — The dredge *Philadelphia*, belonging to the American Dredging Company, was sunk off the foot of Walnut Street, Philadelphia, on August 7th, by the explosion of her boiler. Charles Warner, mate, was killed, and Andrew Anderson, engineer of the dredge, was scalded and bruised so severely that he died four days later. Edward Ramsey, mate, Prince Swain, steward, Alfred Bunting, a government inspector supervising the work of dredging, and John Tantau and William Wilkinson, workmen, were all more or less severely injured. Inasmuch as the daily press has repeatedly stated that "the boiler, which was regularly inspected by the Hartford Steam Boiler Inspection and Insurance Company, was pronounced all right at the last inspection," we deem it proper to say that this is a mistake. We had neither inspected nor insured this boiler. Mr. Washington Jones, a director of the Dredging Company, testified before the coroner, concerning this point, as follows: "All the dredges but this one had been inspected and insured by the Hartford company. . . . This one was a recent purchase. The other dredges had been classed together, and it was hardly thought worth while to do so with this one, as it was in pretty good condition when it was acquired [by the Dredging Company]."

(176.) — On August 9th, as a steam traction thresher was being run along the road in New Sewickley township, near Freedom, Pa., the boiler of the machine exploded and seriously injured the owner, Samuel Wagner of Butler county. Mr. Wagner's skull was fractured and he was otherwise injured. It is believed that he will die.

(177.) — A threshing machine belonging to W. N. Bowers was destroyed by the explosion of the boiler, on August 9th, about four miles north of Zanesville, Ohio. The explosion occurred about two o'clock in the morning, the fires having been banked the night before, so that there might be no delay in starting up the next day.

(178.) — William Oakes, Jr., and George McQuality were seriously scalded on August 9th, by the explosion of a boiler at the Oakes Novelty Works, Decatur, Ill.

(179.) — The boiler of a steam grist mill belonging to Hosea Quimby of Easton, Miss., exploded on August 11th, blowing the mill to atoms. Cornelius Wershoff was slightly injured about the head and arms, and Peter Wershoff was very badly hurt about the head, and was rendered unconscious. It was marvelous that they were not killed outright. The property loss is variously estimated at from $7,000 to $12,000.

(180.) — On August 13th a steam purifier at the Louisville Electric Light Company's plant, Louisville, Ky., exploded, killing Edward Land and dangerously injuring Adolph Schwartz. Charles Wilson was blown through a roof, but escaped with slight injuries.

(181.) — The Rev. J. A. Aspinwall of Washington met with a serious accident on August 15th, near Shelter Island, L. I. A tube failed in the boiler of his steam yacht *Vanish*, while she was racing the *Palos*, owned by Mr. J. B. Edson. The engineer jumped overboard, but not before he had received serious burns and scalds. Mr. Aspinwall was badly burned about the face, hands, and legs, and at last accounts it was not known how serious his injuries might prove. The *Vanish* was built a year ago, and this is the second accident of a serious nature that has happened to her.

(182.) — A young man named Vaughn was fatally injured on August 16th, by the explosion of a boiler in Coventry, near Akron, Ohio.

(183.) — On August 16th a boiler exploded in the Brandeberry mill in Berwick, near Tiffin, Ohio. The mill was wrecked and considerable property in the neighborhood was destroyed. The engineer was at some distance from the mill, and nobody was injured.

(184.) — A small boiler exploded in a cigar factory in Norristown, Pa., on August 16th. Nobody was hurt, as the employes were nearly all at dinner. The damage was small.

(185.) — The boiler of a threshing machine belonging to a man named Reullard, at Georgetown, near Moorhead, Minn., exploded on August 18th. Three men were badly scalded, and one of them is not expected to live.

(186.) — At Medaryville, Pulaski County, Ind., two men lost their lives, on August

18th, by the explosion of the boiler of a threshing machine. August Sitkey, the engineer, was scalded to death, and John Cox was killed by flying pieces of the wrecked boiler. Peter Cox also received injuries that may prove fatal.

(187.) — Levi Boller and his son, Harry Boller, were instantly killed on August 20th, by a boiler explosion in Perry, near Elwood City, Iowa. Logan McElvaine was also injured so seriously that he died a day or two later. The boiler was blown 400 feet away, and the building in which it stood was completely wrecked.

(188.) — The boiler at Baker's mill, four miles northeast of Bagwells, Red River County, Texas, exploded on August 20th, instantly killing two men named Roberts and Horton. Mrs. Eli Matney was dangerously hurt, a flying missile striking her on the side of the face, crushing her cheek bone and tearing away a piece of flesh. Mrs. Baker, Eli Matney, and a man named Moore were more or less severely hurt. One section of the boiler struck Mr. Baker's residence, completely demolishing it. Fortunately, there was no one in the house at the time.

(189.) — A threshing-machine boiler exploded on August 20th, on the farm of H. A. Winan, eight miles north of Casselton, N. D. The engineer is said to have been badly hurt, and Isaac Milner, a prominent farmer, was also seriously injured.

(190.) — Another threshing-machine boiler exploded on August 21st, in the same neighborhood. This machine was owned by George Fowler & Sons, who were threshing on the Dill farm, near Durbin, N. D. Engineer J. M. Campbell was killed, and Fireman Peter Standard was very badly scalded, and it is said that he cannot live.

(191.) — On August 21st a threshing-machine boiler exploded near Byron, Ill. Hiram Burksmith was blown to pieces and instantly killed. Andrew Roos had both legs blown off, and died a short time afterwards. Hiram and John Brass, Henry Ehmen, Charlie and John Luenka, and Edward Nuess, all boys ranging from 9 to 16 years of age, were badly scalded and maimed. The two Luenka boys have since died, and Dr. Clinton Helm, one of the attendant physicians, stated that three of the remaining victims cannot survive. The thresher was completely destroyed. The fly-wheel of the engine was picked up 500 feet away, and pieces of iron were blown through the side of a house 20 rods distant.

(192.) — Still another threshing-machine boiler exploded, on August 22d, in North Dakota, on Edward Jensen's farm, near La Moure. John Lind, a well-known resident of the county, was killed outright, and Louis Berg, the fireman, was blown 300 feet, and was dead when found. Frank Welsh, a band cutter, was badly cut. Orrin Clark, engineer, had his left shoulder dislocated and his left arm broken, and received scalds. H. M. Townsend had several ribs broken and was otherwise badly bruised. Gilbert Johnson received a bad cut on the side of the neck. Two horses were also killed.

(193.) — A slight boiler explosion occurred, on August 23d, in the office of the *Journal*, at Ithaca, Mich. Some slight damage resulted, but nobody was hurt.

(194.) — A boiler exploded, on August 23d, in Blenheim, near Baltimore, Md., killing Andrew Hammond and severely scalding Christopher Cochran.

(195.) — On August 18th, a boiler exploded in Sites & Kellenberger's flouring mill, in Newark, Ohio. Frank Gates was seriously scalded about the face, neck, and hands.

(196.) — By the explosion of a boiler in Kramer's mill, Frankfort, Ind., on August 24th, John Vermillion and William Jackson were killed. A section of the boiler demolished a cooper shop near by, and injured a workman named Barto. A number of other persons received slight injuries from flying fragments. The mill was completely destroyed. It is said that Mr. Kramer estimates his property loss at $10,000, and the damage to surrounding property is said to have been $3,000.

(197.) — A threshing-machine boiler, belonging to Nathan Keeney, exploded near Atchison, Kan., on August 24th. We did not learn further particulars.

(198.) — On August 26th, as Herbert A. Beidler and a party of friends were taking a trip around Lake Geneva, Wisconsin, on his steam yacht *Cygnet*, a flue failed in the boiler, and the engineer, George Smith, was terribly and perhaps fatally burned.

(199.) — On the morning of August 29th, while a steam launch belonging to the new cruiser, *Cincinnati*, was on the way to Greenport, L. I., to get the mail, an accident of some kind occurred to the boiler, and the engineer was scalded. Late in the afternoon of the same day, while the launch was steaming in from Gardiner's Bay, two of her flues failed, and the engineer was badly scalded again.

(200.) — A threshing machine boiler, belonging to John H. Miller, exploded on August 30th, five miles west of Muncie, Ind. There were about fifty men in the vicinity, but, marvelously, no one was injured in the least.

(201.) — On August 30th, a boiler exploded at Stony Brook, near Fergus Falls, Minn. Hans Harvig, engineer, was badly crushed, and died instantly. His father, Knute Harvig, who was firing at the time of the explosion, was struck in the head by a flying fragment and instantly killed. Tollof Anderson, who was 75 feet away, was struck in the thigh by a piece of iron, and injured so badly that he died four hours later. H. T. Harvig was badly scalded, but may recover. Both heads of the boiler were blown out. The cause of the explosion is not known.

(202.) — A serious accident occurred on August 30th, in connection with the exposition at Hornellsville, N. Y. The boiler of a small engine used to drive a cream separater exploded, and a Mr. Carpenter, who happened to be near by, was seriously if not fatally injured about the face and groin. Several other persons were seriously burned about the face and hands. Pieces of the boiler were found a quarter of a mile away.

(203.) — One of the two large boilers at the West Washington street power house of the Citizens' Street Railroad Company, Indianapolis, Ind., exploded on August 31st, causing an estimated damage of $6,000, temporarily crippling the street-car system, and slightly injuring Michael Egan, John Gallagher, and a Mr. Murphy. The walls of the building were considerably injured, holes ten feet wide were opened in the sheet-iron roof, and the iron smoke-stack, 75 feet high, was tipped into a dangerous position.

His Inspiration.

"Horrors, what an obscure hand you write!" said the editor to the new space writer, as he turned in a bit of poetry.

"Oh, it's plain enough," interjected the poet hastily. "The rhymes and the meter will help the compositor out, and there'll not be the least bit of trouble if they follow copy." And the copy went hastily up to the composing room. . . .

"Say-ay, what dod-gasted chump's been sendin' in his Chinese laundry bill for copy?" wildly yelled out Slug 10, wiping a sudden burst of perspiration from his forehead and glaring at his last "take." "I can't make head or tail out of this thing."

"Well, Chinese or no Chinese," cried the hurrying foreman, "make whatever you can out of it, and snag it up in mighty short order, for we're late now."

And the type fairly jumped from the case into the stick. . . .

"Good Cæsar!" gasped the proof-reader, clutching at his brow, "are my eyes failing, or is this a premonition of nervous prostration?" Then he rubbed his eyes and stared. "By the gods! either I've got the blind staggers or Slug 10's on a royal toot!"

At that instant a scream came down the spout: "Rush that proof along, for heaven's sake. We're late."

The proof-reader groaned, galloped down the column, hesitated, and then desperately thrust the slip into the tube, huskily murmuring, "I compared it with the copy, and that's as near as I can get to Hebrew these days." . . .

That night the new space writer hurriedly wrapped up and addressed a copy of the issue, without a glance, and dropped it into the mail with this brief note:

"My onliest Sweet and Dearest Marie: I send you a number of the Sunday supplement containing my little poem. Your face was an ever present inspiration to me when I wrote, and happy thoughts of you inspired every sentence. Here you will find expressed what I have ever felt toward you, but have hardly dared to voice before. Till death, etc."

Miss Marie Cortlandt van Clifton glanced through the tender note, blushed with pleasure, and, hurriedly opening the paper, read:

TO MARIE.

When the breeze from the blue-bottle's blustering bliss
  Twirls the toads in a tooroomaloo,
And the whiskery whine of the wheedlesome whim
  Drowns the roll of the rattattatoo,
Then I dream in the shade of the shally-goshee,
  And the voice of the ballymolay
Brings the smell of stale poppy-cods blummered in blue
  From the willy-wad over the bay.

Ah, the shuddering shoe and the blinketty blanks
  When the punglung falls from the bough
In the blast of a hurricane's hicketty-hanks
  On the hills of the hocketty-how!
Give the rigamarole to the clangery wang,
  If they care for such fiddlededee;
But the thingumbob kiss of the whangery bang
  Keeps the higgledy-piggle for me.

L'ENVOI.

It is pilly-po-doddle and aligobung
  When the lolly-pop covers the ground;
Yet the poldiddle perishes punkety-pung
  When the heart jimmy coggles around.
If the soul cannot snoop at the gigglesome care,
  Seeking surcease in gluggety-glug,
It is useless to say to the pulsating heart,
  "Panky-doodle ker-chuggety-chug!"

And the new space writer and Miss Marie Cortlandt van Clifton are not now engaged.—*Cincinnati Commercial Gazette.*

DR. PULSER: "Did you remove old Bonder's vermiform appendix?"
DR. CUTTER: "Yes."
DR. PULSER: "And was there anything in it?"
DR. CUTTER: "Yes; a cold two-fifty."—*Life.*

The Locomotive.

HARTFORD, OCTOBER 15, 1894.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

Subscription price 50 *cents per year when mailed from this office.*

Bound volumes one dollar each. (*Any volume can be supplied.*)

Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

BY an unfortunate clerical error, the total number of dangerous defects found by our inspectors during the month of July was stated (in our September issue) to have been 1,097. It should have been 1,102, as an addition of the column in question will show.

THE following data concerning the steam power of the world are quoted by our esteemed contemporary, the *Safety Valve.* They are said to have been given out by the bureau of statistics in Berlin: Of the steam engines now working, four-fifths have been constructed during the last twenty-five years. France has 49,590 stationary and locomotive boilers, 1,850 boat boilers, and 7,000 locomotives; Germany, 59,000 land boilers, 1,700 ship boilers, and 10,000 locomotives; Austria, 12,000 boilers and 2,800 locomotives. The working steam engines of the United States represent 7,500,000 horse-power; Germany, 4,500,000 horse-power; France, 3,000,000; Austria, 1,500,000. This estimate does not include the locomotives, whose number in the world is 105,000, representing a total of 3,000,000 horse-power. The world's steam engines, therefore, aggregate more than 26,000,000 horse-power, equivalent approximately to the work of 1,000,000,000 men.

What is a Heat Unit?

When, in ordinary conversation, a person uses the word "heat," there is often some uncertainty about the precise meaning that he intends to convey by it. This uncertainty arises partly from the many figurative meanings of the word, but principally from a confusion of "heat," properly so-called, with "temperature." For example, we speak of the "heat of the day," meaning that part of it which is hot — *i. e.*, the middle of the day. Again, we speak of the "heat of a furnace,"— meaning, really, the *temperature* of the furnace. In the expression "animal heat," on the other hand, the word "heat" is possibly used in its strict sense, and we understand it to mean a *quantity* of some sort or other, which could be measured just as definitely as wood or potatoes can be, if we could only devise some appropriate unit by which to perform the measurement.

In order to get a somewhat clearer idea of the difference between heat and temperature, let us consider a tub of hot water. A thermometer immersed in this water reads (say) 200° Fah.; and under these circumstances many persons would say that the water "contains 200 degrees of heat." Now nothing could be more misleading nor more erroneous than such a statement as that. It should be observed that the only thing we have determined is the *temperature* of the water; and the thermometer would read just the same whether the tub contained a pint of the water, or 40 gallons of it, or a thousand oceans of it. If one should find that a thermometer plunged in the Atlantic Ocean gave just the same reading as a similar one immersed in a gill measure, he surely would not say that the gill of water in his hand contained as much *heat* as the whole Atlantic Ocean. His observation would indicate that the *temperatures* of the two were alike, but that is all.

In order to determine the amount of *heat* in a given body of water, we must first decide upon some convenient *unit of heat*, and then we must find out how many of these units would be required to raise the given mass of water from the freezing point to the given temperature. For example, we might adopt, as our unit of heat, the heat required to melt one pound of ice; and we could then determine how many pounds of ice the given mass of water could melt, in cooling from the observed temperature down to the freezing-point. This method of procedure is quite satisfactory for laboratory purposes, and various forms of apparatus have been devised for putting it into practice, some of which enable us to measure quantities of heat with great precision. Valuable as these "ice calorimeters" are in the laboratory, they are of little or no use to the engineer, because ice is often expensive and difficult to obtain, and because the apparatus necessary to ensure accuracy in measuring large quantities of heat by this method would be so cumbersome that it could not be transported from place to place.

For general use in engineering we are obliged, therefore, to adopt some other unit for heat-measurement. We might, for example, define a "unit of heat" as the quantity of heat required to raise the temperature of a pound of some given substance one degree; and, in fact, this is the kind of unit that is actually used in practice. We could base the proposed unit on any substance we choose, but as water is both cheap and convenient, and as it can nearly always be obtained in a condition of reasonable purity, it has been adopted by universal consent; and a "heat unit" is defined to be that quantity of heat which will raise the temperature of one pound of water one degree.

Before we could adopt any such general definition as this, we should have to find out whether or not it takes the *same* quantity of heat to raise the temperature of a pound of water from (say) 39° to 40°, that it does to raise it from (say) 210° to 211°. If this is not the case, it will be necessary to modify our definition of a "heat unit" to the extent of specifying at what temperature the pound of water is to be taken. To guard against a possible ambiguity of this kind, some writers define a heat unit as "the quantity of heat required to raise the temperature of a pound of water from 39° to 40°;" while others define the temperature range to be "from 32° to 33°," and others "from 59° to 60°."

In order to judge of the importance (or unimportance) of specifying the temperature of the water in defining the heat unit, let us examine some of the experimental data that have been obtained relative to this point. If the heat required to raise the temperature of a pound of water one degree were the same, all the way from the freezing point to the boiling point, it would follow that if we should stir together two pounds of water, one of which is at 212° and the other at 32°, the temperature of the mixture would be $\frac{212° + 32°}{2} = 122°$; and conversely, if the temperature of the mixture is found to be *different* from 122°, we should know that the quantity of heat required to raise the temperature of a pound of water by one degree is *not* the same at all points on the thermometer scale. Careful experiments, performed after taking all possible precautions against loss of heat by radiation and conduction, have shown that when a pound of water at 212° is mixed with a pound of water at 32°, the temperature of the mixture is 122.29°. This shows that the quantity of heat required to raise the temperature of a pound of water one degree is *not* the same at all points of the thermometer scale, but it indicates, at the same time, that the total variation between the freezing point and the boiling point is very slight. Similar experiments, made by mixing water at other temperatures, give this same result; and hence we conclude that although a "heat unit" is not the same at all temperatures, the variation in its value is so slight that for most purposes it can be neglected. In calculating tables of the properties of steam and water, allowance is made for the fact that the "specific heat" of water is not the same at all temperatures; but in all the ordinary work of testing boilers and engines, and laying out steam-plants and heating-systems, it is customary to consider the specific heat of water to be *constant*; and the "heat unit" is defined simply as "the quantity of heat that will raise the temperature of one pound of water one degree."

When we say that a pound of steam, in condensing, gives out 967 heat units, we merely mean that it gives out an amount of heat that would be sufficient to raise the temperature of 967 pounds of water 1°, or 96.7 pounds of water 10°, or 9.67 pounds 100°, etc. Similarly, when we say that a pound of good coal gives out 14,000 heat units when burned, we mean that each pound of the coal can heat 14,000 pounds of water 1°, or 1,400 pounds 10°, or 140 pounds 100°, etc. And finally, when we say that the "mechanical equivalent of heat" is 779 foot-pounds, we only mean if a weight of 779 pounds should fall one foot, the work it would do would be just sufficient to raise the temperature of a pound of water 1°; and, conversely, if we could utilize (by means of a steam engine or otherwise) all the heat that a pound of water gives out when it cools 1°, this heat would be just sufficient to raise a weight of 779 pounds through a height of one foot.

The Recent Eruption of Kilauea.

This great volcano has been active for several months past, the principal characteristic being a remarkable rise and fall of melted lava within the crater. L. A. Thurston gives the following among other particulars in the Pacific *Commercial Advertiser*. In March, 1894, the lava had risen almost to the top of the crater, the rise being 447 feet in 19 months.

On the evening of July 6th a party of tourists found the lake in a state of moderate activity, the surface of the lava being about twelve feet below the banks. On Saturday, the 7th, the surface of the lake raised so that the entire surface was visible from the Volcano House. That night it overflowed into the main crater, and a blow hole was thrown up some 200 yards outside and to the north of the lake, from which a flow issued. There were two other hot cones in the immediate vicinity which were thrown up about three weeks before. On Sunday, Monday, and Tuesday, July 8th, 9th, and 10th, the surface of the lake rose and fell several times, varying from full to the brim to 15 feet below the edge of the banks.

On the morning of the 11th the hill was found to have sunk down to the level of the other banks, and frequent columns of rising dust indicated that the banks were falling in. The lake had fallen some 50 feet, through the escape of the lava by some subterranean passage, and the wall of the lake formed by the hill was falling in at frequent intervals. The lava in the lake continued to fall steadily, at the rate of about 20 feet an hour from 10 o'clock in the morning until 8 in the evening. There was scarcely a moment when the crash of the falling banks was not going on. As the level of the lake sank, the falling rocks of the banks, undermined by the escape of the lava, caused a constantly increasing commotion in the lake as they struck the surface of the molten lava in their fall. A number of times a section of the bank from 200 to 500 feet long, 150 to 200 feet high, and 29 to 30 feet thick, would split off from the adjoining rocks, and with a tremendous roar, amid a blinding cloud of steam, smoke, and dust, fall with an appaling down-plunge into the boiling lake, causing great waves and breakers of fire to dash into the air, and a mighty "ground-swell" to sweep across the lake, dashing against the opposite cliffs like storm waves upon a lee shore. Most of the falling rocks were immediately swallowed up by the lake, but when one of the great downfalls referred to occurred, it would not immediately sink, but would float off across the lake, a great floating island of rock.

As the lava subsided, most of the surrounding banks were seen to be slightly overhanging, and as the lateral support of the molten lava was withdrawn, great slices of the overhanging banks on all sides of the lake would suddenly split off and fall into the lake beneath. As these changes took place the exposed surface, sometimes 400 feet across and upward, would be left red hot, the break, evidently, having taken place on the line of a heat crack which had extended down into the lake. From 6 to 8 o'clock the entire face of this bluff, some 800 feet in length and over 200 feet in height, was a shifting mass of color, varying from the intense light of molten lava to all the varying shades of rose and red to black, as the different portions were successively exposed by a fall of rock and then cooled by exposure to the air. During this period the crash of the falling banks was incessant. Sometimes a great mass would fall forward like a wall; at others it would simply collapse and slide down, making red-hot fiery landslides; and again enormous boulders, as big as a house, singly and in groups, would leap from their fastenings and, all aglow, chase each other down and leap far out into the lake.

The awful grandeur and terrible magnificence of the scene at this stage are indescribable. As night came on, and yet hotter recesses were uncovered, the molten lava which remained in the many caverns leading off through the banks to other portions of the crater began to run back and fall down into the lake beneath, making fiery cascades down the sides of the bluff. There were five such lava streams at one time. The light from the surface of the lake, the red-hot walls, and the molten streams lighted up the entire area, bringing out every detail with the utmost distinctness, and lighted up a tall column of dust and smoke which arose straight up. During the entire period of the subsidence the lava fountains upon the surface of the lake continued in action, precisely as though nothing unusual was taking place. — *Scientific American.*

THE late Bishop Selwyn of New Zealand and Melanesia was well known during his university days as a devotee of the noble art of self-defense. He incurred a great deal of animosity from a certain section in New Zealand, owing to his sympathy with the Maoris during the war. One day he was asked by a rough in one of the back streets of Auckland if he was "the Bishop who backed up the Maoris." Receiving a reply in the affirmative, the rough, with a "Take that, then," struck his lordship in the face.

"My friend," said the bishop, "my Bible tells me that if a man smite thee on one cheek turn to him the other," and he turned his head slightly the other way. His assailant, slightly bewildered and wondering what was coming next, struck him again. "Now," said his lordship, "having done my duty to God, I will do my duty to man," and taking off his coat and hat he gave the anti-Maori champion a most scientific thrashing.— *Home Journal.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES — VOL. XV. HARTFORD, CONN., NOVEMBER, 1894. No. 11.

Concerning Cast-iron Flanges.

The large mouth-pieces of rendering tanks and upright bleachers are usually made of cast-iron, and are provided with flanges through which pass the bolts that hold the covering plate in position. It is to these flanges that we wish to call attention in the present article.

Consider, for example, the mouth-piece illustrated in Fig. 1. The internal diameter of the casting, in this case, was thirty inches, and a steam pressure of 100 pounds to the square inch was carried, making the total load on the cover-plate some 71,000 pounds. This load was transmitted to the flange of the casting by bolts, two of which are shown in the illustration. There was a sufficient number of bolts to withstand the load safely, and the main body of the casting was also stout enough to be safe. We desire to call

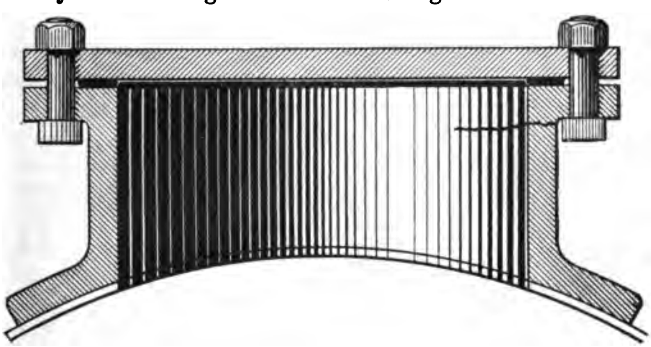


FIG. 1. — A CAST-IRON FLANGE WITHOUT BRACKETS.

attention, however, to the fact that since the cover-bolts are not in line with the body of the casting, the strain in the flange is neither a simple shear nor a simple pull. In fact, the flange is in the condition of a beam loaded at one end and fixed at the other; and therefore the horizontal strain at the root of the flange will be a *tension*, and its magnitude can be easily computed by means of the usual rules for beams. But the strain at the root of the flange is not due to the steam pressure alone, for in turning up the nuts on the bolts so as to secure a tight joint we shall produce a very material addition to the strain on the flange, which we shall have to take into account. By making certain reasonable assumptions concerning the strain on the bolts due to screwing up the nuts, we find that in the case under consideration the tensile strain on the main casting at the root of the flange was about 4,100 pounds. We cannot safely rate the tensile strength of cast-iron higher than 15,000 pounds, and hence the factor of safety in the present instance is only about 3⅔, whereas it ought to be about 10. The packing being all within the line of bolts, it is easy to see that if a slight leakage should occur, and the attendant should attempt to check it by screwing up the nuts unreasonably, the tensile strain on the casting would be still further increased, and the actual factor of safety correspondingly reduced. It will be evident from what has been said already, that the flanges of large cast-iron mouth-pieces should be carefully considered both by the designer and by the builder, even if the casting were equally sound throughout. It is

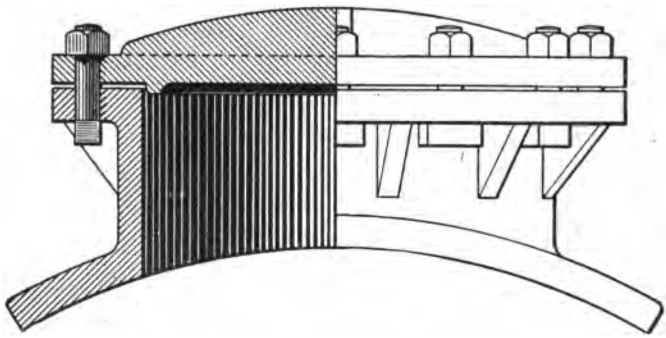
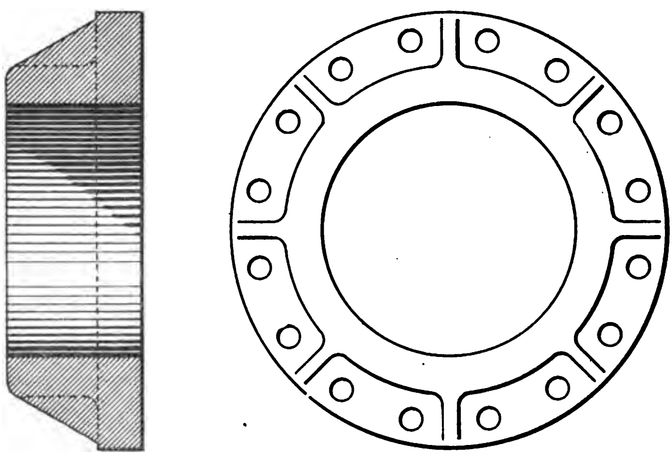


FIG. 2.—A PROPER CONSTRUCTION FOR CAST-IRON MOUTH-PIECES.

well-known, however, that castings are liable to be spongy at the root of the flange, where our analysis shows them to be weakest; and this fact should also be considered in designing and constructing them.

Lest any of our readers should fancy that we have exaggerated the dangers of cast-iron flanges, let us say that we have known flanges *three inches thick* to break at the root



FIGS. 3 AND 4.—DESIGN FOR A CAST-IRON FITTING FOR A TEN-INCH STEAM PIPE.

from the causes we have described. We also have another case in mind in which an incipient crack occurred at the root of the flange of the mouth-piece of a digester carrying 100 pounds pressure, and although it was promptly discovered, it had extended along the mouth-piece for a distance of *twenty inches* (as indicated by the irregular line in Fig. 1), before the pressure in the digester could be reduced.

In order to provide against the breaking of cast-iron flanges care should be taken to make them abundantly thick; or, which we consider a better plan, they may be made with *brackets* running from the flange to the body of the casting at frequent intervals, as shown in Fig. 2. The cover may be flat, if it is made thick enough, but it is much better to provide ribs on the upper side of it, as in Fig. 2. Such ribs possess great stiffening power and add much more to the strength of the cover than the same amount of metal would if distributed in any other way. When the covers of digesters and bleachers have to be frequently removed, it is usual to slot the bolt-holes so that the bolts can be removed by merely loosening the nuts. They are also frequently so arranged that each bolt turns about a horizontal pin that passes through holes in a pair of parallel brackets cast on the body of the mouth-piece. The discussion of the features is reserved for a future issue, however, as we are here concerned merely with the strength of cast-iron flanges.

The reasoning that we have given in connection with mouth-piece flanges is also applicable to the cast-iron flanges used in connecting large steampipes that are designed to carry heavy pressures. Figs. 3 and 4 show a front view and a sectional view of a bracketted flange connection as designed for a ten-inch steam main, and a design substantially similar may be used for other sizes of pipe.

Inspectors' Report.

SEPTEMBER, 1894.

During this month our inspectors made 7,824 inspection trips, visited 15,253 boilers, inspected 6,542 both internally and externally, and subjected 652 to hydrostatic pressure. The whole number of defects reported reached 11,292, of which 1,195 were considered dangerous; 31 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	900	39
Cases of incrustation and scale,	1,918	59
Cases of internal grooving,	78	13
Cases of internal corrosion,	587	28
Cases of external corrosion,	805	45
Broken and loose braces and stays,	159	27
Settings defective,	432	43
Furnaces out of shape,	407	19
Fractured plates,	255	39
Burned plates,	252	26
Blistered plates,	245	17
Cases of defective riveting,	1,440	114
Defective heads,	123	19
Serious leakage around tube ends,	1,895	409
Serious leakage at seams,	508	48
Defective water-gauges,	402	67
Defective blow-offs,	168	54
Cases of deficiency of water,	20	5
Safety-valves overloaded,	84	18

Nature of Defects.	Whole Number.	Dangerous.
Safety-valves defective in construction, - - - -	73 -	- 20
Pressure-gauges defective, - - - - - -	413 -	- 34
Boilers without pressure-gauges, - - - - -	49 -	- 49
Unclassified defects, - - - - - - -	79 -	- 3
Total, - - - - - -	11,292 -	- 1,195

Boiler Explosions.

September, 1894.

(204.)— On September 1st, a boiler exploded at McKay, Dingman & Co.'s oil well near Titusville, Pa. Jacob F. Toy was instantly killed, and three other men, who were in the derrick, had narrow escapes. According to the Titusville *Herald*, "the boiler had just been filled and fired up, and while the men were at work about the well and not using the engine, the steam began blowing off through the safety-valve. Not wishing to waste water and fuel, one of the men employed about the well took a pair of tubing tongs and hung them on the end of the safety-valve lever and stopped the valve from allowing the steam to escape. The work at which the men were engaged lasted longer than they expected, the tongs were forgotten, and the steam ran up so high that the boiler was blown to pieces by the over-pressure. The fact of weighting down the safety-valve lever was forgotten until some days after the explosion, and for that reason no evidence of the fact was given before the coroner's jury at the inquest."

(205.)— A boiler exploded with terrible force, on September 1st, in Stanton's Riverside laundry at Janesville, Ill. The laundry was in the basement of the Mechanics' and Merchants' Savings Bank. The explosion demolished the entire rear end of the building, destroying not only the laundry but the machinery in an adjoining dye-house. Kittie Connors, Bertha Greenwald, Gustave Haise, Julia Kinna, A. A. Kapelsky, and Cornelius Roberts were injured. One account of the explosion says that "the engineer had gone out after a pail of water just before the accident, returning in time to get a brick thrown through his hat." The property loss amounted to some thousands of dollars.

(206.) — On September 3d a boiler exploded in Sabina, Ohio, killing James Robinson, and frightfully scalding William Mercer, who is not expected to recover. Parts of the boiler were driven through J. W. Hill's house, three hundred yards away. It is reported that the boiler had no steam gauge, and that the safety-valve was wired down.

(207.) — A boiler exploded, on September 4th, in Hutchispon's saw-mill, near Frankfort, Tenn. George Taylor was killed outright, and several other men were injured.

(208.)— J. A. Gagnon's mills, across the St. Maurice river from Three Rivers, Quebec, were wrecked, on September 7th, by a boiler explosion. Samuel Beaumier was instantly killed, and his body was found a hundred feet from the scene of the explosion. Philip Gaudet, Daniel Loranger, Napoleon Sanstette, Philip Mercier, Dolphus Rocheleau, Joseph Carboneau, and a father and son named Murdock, were injured.

(209.)— A boiler exploded, on September 8th, in the Warwick tool works, Wheeling, W. Va. The damage was slight, as the pressure, at the time of the explosion, was only twenty pounds.

(210.) — While Charles Cory was pumping an oil well near Bradford, Pa., on September 8th, he was instantly killed by the explosion of a boiler.

(211.) — A cotton-gin boiler exploded, on September 8th, at Una, Texas. Nobody was hurt.

(212.) — There was a boiler explosion, on September 11th, in William Moberly's flouring mill, on Paint Lick, near Richmond, Ky. Thomas Moberly was scalded internally, and cannot live. William Marr and two other men were also painfully injured.

(213.) — On September 14th, a boiler exploded in the gas house at New Castle, Pa. The boiler was hurled through the roof, and landed in a field about 60 feet away. The building was badly wrecked. Several men were working in the gas house at the time, but all escaped injury.

(214.) — On September 14th, the new passenger steamer *Unique* left Port Huron, Mich., for Detroit, on her second trip. When she was opposite St. Clair a flue failed in one of her boilers. The fireman, James Primrose, was fatally scalded.

(215.) — A boiler exploded, on September 19th, at the Harold Mill Company's lumber mill on Conecuh river, six miles east of Brewton, Ala. It is said that two hundred thousand feet of lumber were destroyed in the fire that followed.

(216.) — On September 19th, the steam boiler attached to a portable feather renovator, operated by Messrs. Seely & Mott, blew up on the street at South Haven, Mich., throwing both Seely and Mott some distance. Mr. Seely was seriously, and perhaps fatally, injured.

(217.) — A boiler exploded, on September 20th, in Frank Carver's mill, near Sulphur Springs, Ark. William Ward was killed outright. George Carver, a brother of the owner of the mill, was badly cut on the face and legs; Engineer Locial was dangerously scalded; one boy and four men, whose names we have not learned, were badly cut and burned. Another man had his head blown off, and seven more were fatally injured. The mill was entirely demolished, and the noise of the explosion was heard for miles. The property loss was about $10,000.

(218.) — Engine No. 89, drawing a freight train of thirty cars on the Delaware railroad, exploded its boiler, on September 20th, when about a mile and a half south of Harrington, Del. The crown-sheet failed, and the fire was blown out of the furnace door. All the coal was blown out of the tender, and with such violence that part of it was driven through the end of the first freight car. Engineer John Parsons, Fireman Albert C. Dunn, and Brakeman C. E. Ellingsworth were injured. Brakeman Charles Lee jumped from the cab and escaped injury.

(219.) — On September 20th, a boiler exploded in Boyd's saw-mill, killing Redfield Reid, Nathan Henneck, and George Martin. Several others were badly injured, and all the buildings in the neighborhood were demolished.

(220.) — A saw-mill boiler, six miles east of Florence, Kan., exploded on September 21st. Engineer Smith had his collar bone broken and his shoulder badly torn.

(221.) — On September 21st, a boiler exploded in W. H. Kimball's mill, in Winder, Ga. John Hill received a bad fracture of the skull, together with various cuts and bruises, and it is believed that he will die. Three other men were severely scalded.

(222.) — On Friday, September 21st, Cyrus Rissmiller and Harrison Hahn of Wind Gap, Pa., hired a cider press from Luther Miller. Next morning Hahn and Howard

Hildebrand fired up the boiler, and were about to begin operations, when suddenly the boiler exploded, and the air was immediately alive with machinery and bits of iron. Hahn, who was standing near by, was deposited in an adjoining cabbage patch. Hildebrand was seriously scalded about the head and neck.

(223.) — The boiler head of a locomotive on an east-bound train blew out, on September 24th, as the train was passing through the snow sheds near Blue Canton, Cal. Engineer Goddard and Fireman Lipscomb were severely injured, and Lipscomb died a few hours later.

(224.) — A boiler exploded, on September 24th, in a meat shop in Marion, Wis. Nobody was hurt.

(225.) — On September 24th, a cast-iron header failed on one of the safety boilers of the Consumers' Ice Company in San Francisco, Cal. Nobody was injured.

(226.) — A heating boiler exploded in the court house at Mercer, Pa., on September 25th. The damage was insignificant.

(227.) — By the explosion of a threshing-machine boiler on William Cain's farm at Crystal, N. D., on September 25th, William Hawthorne, Christopher Burns, F. A. Barranger, and Nicholas Phillipps were killed outright, and Charles Shepherd and Alexander Proux were so badly injured that they died shortly afterwards. George Proux, Morris Gettry, and Thomas Morgan were also fearfully injured. Gettry's skull was fractured. W. Rice, H. Haeton, and Norman Montgomery received lesser injuries.

(228.) — Harrison Wilder's cotton gin, seven miles east of Calvert, Texas, was destroyed, on September 27th, by a boiler explosion. Wilder and two boys were killed.

(229.) — Four boilers exploded, on September 28th, at the Schuylkill colliery, near Mahanoy City, Pa. The boiler house was destroyed. Fortunately all the hands escaped injury. The breaker took fire, but was promptly extinguished.

(230.) — A slight boiler explosion occurred, on September 28th, at the Hubinger electric light plant in Keokuk, Iowa. Nobody hurt.

Machinery and Labor.

The nineteenth century man has good reason to be proud of himself, for he has wrought a greater change in the material and social aspects of the world than ever was seen in a thousand years before. It is true that there have been civilizations before his — some of them very splendid — but they were local and parochial compared with that which is now rapidly enveloping the globe. Even the achievements of the Roman Empire, extending over long centuries, did not equal those within the memory of living men. The past civilizations rested on two bases — intellect and military — sometimes one and sometimes the other predominating. These sufficed for creating great cities and communities, for evolving systems of law, and for organizing and controlling armies. But they did little towards freeing man from the curse of living by the sweat of his brow. Human muscles were nearly the sole source of mechanical power. The trireme was rowed by slaves, the mill was turned by women, editions of books were produced by the pen, and all manufactures were the result of heavy toil. It was only by enslaving whole nations that the refinement and luxury of Roman society was rendered possible. By skillful organization, and above all by the stern repression of wars and feuds, the labor of Europe was turned to the best account, and so civilization prospered. Its limit, however, was marked by the amount of work a man could do in a day. But by the invention of the steam engine, this limit was swept away, and humanity was freed from the heaviest part of its burden of toil. No longer does the slave tug at the oar, the miner carry up the ore on his back, or the traveler tramp wearily from dawn to dark. But not only did the steam engine undertake the hard work of the world, but it begot machinery that rivals the best handicraft in skill, and exceeds it a thousandfold in production, rendering one man able to undertake the work of many. It is this relaxation from hard manual toil, and the ability to produce more than is needed to maintain life, that lies at the root of that wonderful development of our times.

A period of change always brings suffering to some, even if the general effect be one of great improvement. In the rearrangement of social conditions some of the old parts do not fit into the new scheme, and are flung out, or else need to be greatly altered before they can be utilized. At times during this century the changing conditions have caused immense suffering, which found expression in anti-machinery riots, Chartism, and other popular movements, and now some of these are being revived in a new form. In an introductory address, delivered by Mr. John Inglis to the Institution of Engineers and Shipbuilders in Scotland last Tuesday, there was a reference to a Hyde Park orator, who spoke of Labor as crucified between two thieves — Capital and Machinery. Little must the orator have known of the history of labor to refer to its present condition, with its powerful trade unions and an eight-hours bill looming in the near future, as crucifixion. Probably, however, as Mr. Inglis suggests, he was more intent upon using a sounding figure of speech than of finding one that represented the truth, and that all he wished to enforce was that the misery of labor was embittered by the presence of capital and machinery.

There is, unfortunately, no doubt that labor is passing through a period of trial, and that the pressure upon it will increase as we get farther into winter. It is only natural that at such a time men should cast about to find the reason, and that those with untrained minds should seize upon the first that comes to hand, and repeat it until it becomes accepted by persons like themselves. The proposition, that if it required two men to do the work now accomplished by one, there would be a greater demand for labor, appears so charmingly simple when launched with rhetorical skill at a popular gathering, that it is pretty sure to find a good deal of acceptance, and be the means of leading people into economic error. The mob orator has an immense advantage over the man that discusses such a question scientifically, in that he demands no thought on the part of his audience. At a time like the present, when many people are beginning to doubt the value of the greatest blessing — next to settled government — ever evolved by the human race, it is essential that those who are better informed should speak out, and we are glad to see that Mr. Inglis adopted the course we have persistently advocated of making his inaugural address the expression of his great experience and mature thought, instead of following the usual custom of giving a string of incomplete and unsatisfactory statistics.

He summed up the popularly alleged causes of the present slackness of demand for our wares, and of the abasement of ocean freights, under four heads, *viz.:* monometallism, labor disturbances, the private ownership of land and minerals, and over-production. The first three he dismissed very briefly. He has no faith in bi-metallism; he deplores industrial wars, but points out that, at any rate, they are an antidote to over-production; as for land tenure, he believes that the usages connected with the occupation of land have yet to be completely adapted to the new environment of which modern mechanical appliances are mainly the cause, and that this adaptation, like all radical changes, will probably continue to be attended by much suffering to individuals. To the fourth alleged cause — over-production — he devotes greater space. In this relation he says: "The truth about the matter I believe to be that the condition of things, which we agree to call over-production, or depression of trade, is not primarily due to machinery, but, in a great measure, to the reckless borrowing by impecunious States, communities, and associations, encouraged by the imprudence of financiers, and the credulity of the public as to the powers of governments and other debtors to fullfil their obligations. The abnormal and unwarranted demand for goods from those put in easy possession of borrowed funds is rapidly met by the setting in motion of modern machinery — itself partly brought into existence by the necessity temporarily created. High prices become the rule, until the inevitable glut takes place, when there follows the revulsion to prices that are unremunerative. The fall in values is, perhaps, increased in rapidity by machinery, but the unwholesome stimulus is not immediately traceable to mechanical appliances." This explanation is more satisfactory to the capitalist than to the laborer, for the latter seldom reaps such a harvest during the good times as will carry him comfortably over the periods of depression. It is undoubtedly true that machinery does displace manual labor very often, and that it does not always produce such a lowering in price that the increased demand reinstates the men who have been superseded. Mr. Inglis finds from the census returns, by Messrs. Booth, Hobson, and Marshall, that while the output of textile goods has enormously increased, the proportion of labor employed in their production has continuously diminished. Again, while the rural population has declined but little, the number of persons engaged in agricultural labor has largely decreased, and this falling off began long before the comparatively recent fall in rents, and what is known as the decay of agriculture in this country. What has become of the persons that would, had the strict ratio been maintained, have followed these pursuits? Evidently they have turned to others, either old or new. Commercial pursuits, shopkeeping, transport, and other industries show an increase beyond their due proportions; shipbuilding afforded employment to 40 per cent. more persons in 1891 than 1881; the making of machinery and tools required an increase of 28 per cent. during the decade; those engaged in road traffic and in the industries connected with it show an increase; coal miners have grown in numbers 35 per cent. in ten years, while the output has only augmented 20 per cent. Of those released from manual labor, many have betaken themselves to professions. Clergymen, lawyers, doctors, teachers, painters, actors, and musicians are far more numerous, proportionately, than they were; and their pleasant lives are all due to machinery.

Indeed, were it not for machinery many of the inhabitants of this kingdom would not exist. The population of England at the Norman Conquest was about 2,000,000; in 500 years it had scarcely doubled. The conditions of life when muscle was the sole motive power, were too hard for all but the exceptionally strong. Professor J. W. Draper has given us a picture of existence in the middle ages. "The houses were of wood, daubed with clay, and thatched with straw and reeds. They had no windows, and, until the invention of the saw-mill, very few had wooden floors. The luxury of a carpet was unknown; some straw scattered in the room supplied its place. There were no chimneys; the smoke of the ill-fed, cheerless fire escaped through a hole in the roof. . . . . The bed was usually a bag of straw, a wooden log served as the pillow." Æneas Sylvius, who afterwards became Pope Pius II, has left an account of a journey he made to the British Isles in 1430. He describes the houses of the peasantry as constructed of stones put together without mortar; the roofs were of turf, a stiffened bull's hide served for the door. The food consisted of coarse vegetable products. In some places they were unacquainted with bread. Crucified labor had not then even the poor consolation of having machinery and capital to share its woes.

The outcry against machinery is, when investigated, found to be directed against its increase, rather than its existence. A proposal for its abolition would raise a torrent of protest. For instance, the veriest Tower Hill demonstrator would be aghast at the railways being put out of use; he knows that it would mean immediate starvation. The fitter does not desire to do the old hard work of hammer and chisel, now better executed by the planing machine. The shipbuilder would be indignant if the ironworker proposed to destroy the converter and the Siemens-Martin furnace, and to return to puddling, because he knows that increased price of plates would mean lessened demand for shipping. Probably every one would be satisfied if the additions of the last four or five years could be done away with. We all like to gather fruit, but we object to the labor of planting trees for posterity. It is the constant change of conditions that presses so heavily on the present generation, and particularly on the working classes. They have to be ever adapting themselves to an altered environment, and the process is very trying to the least apt of them. Unfortunately, this seems to be a law of existence. Were the population absolutely stationary, things might be different. But it always increases, in this country at least, and the moment life becomes easy and pleasant the rate of growth augments to upset the arrangement. What the end will be no one can tell, but at least we know that all great improvements have come out of suffering. In the meantime the best we can do is to try and ease the tight places in the great social machine, and not to enter into rash experiments with undue haste. We see how much individual pain comes from the slow unfolding that occurs naturally, and we may be sure that even were there all the good in the radical schemes of socialists and collectivists that their authors believe, their sudden introduction would be attended with disaster and death to immense numbers. In spite of the misery and destitution that exist, it is impossible to deny that the conditions of living have improved in a marvelous manner during the last fifty years; that the nation is better fed and clothed, and has far more social and intellectual enjoyments. It may be that we have not followed the best or the wisest course, but it is certain that to retrace our steps would carry us to privations and sufferings of which we can form no adequate conception.— *Engineering.*

Word has been received from London, Eng., of the explosion of a boiler on the steamer *Tannadice* shortly after she had left Port Louis for Bombay. Four men were killed and several others were injured. The vessel was also seriously damaged, and she returned to Port Louis. The accident occurred about September 5th.

The bold Knight du Bois pranced up and down before the castle of Montgomery on his gaily caparisoned steed.

Presently a fair lady looked out over the portcullis towards him.

And she was very fair; so fair that the bold Knight du Bois stopped his prancing steed to look at her. She was not agitated by his gaze, but continued watching the knight.

He waved his sword at her, and still she was unmoved.

"By my halidom!" he shouted as he looked upon her.

She shook her head.

"No," she replied, "no, we don't want to buy anything to-day.

And, so saying, she disappeared.

[N. B.— Our scissors editor contributes this, but cannot remember where it came from.— Ed.]

The Locomotive.

HARTFORD, NOVEMBER 15, 1894.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

AN explosion took place on October 25th on board the French cruiser *Arethuse*, at Brest, while her engines were being tested preparatory to sailing for the east in order to reinforce the French squadron in Chinese waters if such a step be necessary. Six men were killed and twenty others were badly scalded. The first report of the disaster magnified it considerably, and it was generally believed that one of the cruiser's boilers had burst. It is now believed, however, that the explosion was due to the bursting of a steam-pipe. The accident caused great excitement ashore and about the docks, and this was increased when it was discovered that fire had broken out aboard the cruiser. The situation on board finally became such that her commander brought her alongside one of the docks, and the flames had to be extinguished by the crew, reinforced by detachments of marines and sailors from the dockyard, before the wounded could be removed.

THE *Annual Report*, for 1894, of the Chief of the Bureau of Steam Engineering, has been duly received. Among other interesting information in the *Report*, we find the following: "The rapid destruction of copper piping in several vessels has already caused serious embarrassment, and the reason for this deterioration has not yet been determined to an absolute certainty. As it always happens to a copper pipe conveying or surrounded by salt water, and as the injection or delivery pipe to a pump, or the coil of a fresh water distiller, is the part attacked, and as the deterioration occurs only in steel ships fitted with dynamos, it is thought that the injury may be caused by electrolytic action; for the copper of which the pipes are made is known to be of the very best quality, absolutely free from foreign matter, and therefore not affected by the corrosive action of salt water. In fact, precisely similar pipes, made of the same material, last almost indefinitely in iron vessels like the *Alert* or *Ranger*, which have no dynamos. Steps are being taken to find out the true cause of this rapid destruction and the means by which it may be prevented."

IT has been seriously proposed to construct a railroad up the Jungfrau, a famous mountain in Switzerland, whose ascent is almost as difficult and dangerous as that of the Matterhorn. The Jungfrau is nearly 14,000 feet high, and its summit is well up in the region of perpetual snow and ice. It is proposed to carry the railroad up in the usual manner as far as practicable, and then to strike boldly into the mountain and complete the ascent by means of a spiral tunnel. When the summit of the mountain has been so nearly approached that it is no longer possible to give the ascending spiral of the tunnel a sufficient radius, the railroad will come to an end, and the journey will be completed by means of an elevator. It is proposed to blast off the summit of the mountain sufficiently to provide a suitable foundation for a hotel. If this project is carried out, it will certainly be the most striking example of railroad engineering that the world has yet seen. There are tunnels galore, and some few of them form spirals of a single turn or so; but, so far as we know, there is no example of such a gigantic corkscrew as the Jungfrau will require.

The Pitting of Boilers.

In an article recently published, M. Olroy, a French engineer, gives the result of his investigation into the pitting of boilers. Pitting is particularly likely to occur if a water very free from lime is used in a clean boiler. The pits take the form of conical, or, more frequently, spherical depressions, which are filled with a yellowish-brown deposit, consisting mainly of iron oxide. The volume of the powder is greater than that of the metal oxidized, so that a blister is formed above the pit, which has a skin as thin as an egg-shell. This skin contains, usually, both iron oxide and lime salts, and differs greatly in toughness. In many cases it is so friable that it breaks with the least shock, falling to powder, while in other cases the blister detaches itself from the plate as a whole. An analysis of the powder in the pits showed it to consist of 86.26 per cent. of peroxide of iron, 6.29 per cent. of grease and other organic matter, and 4.25 per cent. of lime salts, the remainder being water, silica, aluminium, etc. The skin over the pits was found to contain 38 parts of calcium carbonate, 12.8 parts of calcium sulphate, and 32.2 parts of iron oxide, with about 8 per cent. each of magnesium carbonate and insoluble matter. Feed heaters often suffer badly from pitting, particularly near the cold water inlet, and in boilers the parts most likely to be attacked are those where the circulation is bad, especially if such portions are also near the feed inlet. In locomotives the bottom of the barrel is most frequently attacked, and the largest ring. The steam spaces are generally free from pitting unless the boiler is frequently kept standing with water in it. As the water evaporates, pitting is then likely to occur along the region of the water line, a part which, in a working boiler, is generally free from attack. This is especially the case if longitudinal joints of the boiler are liable to be exposed by the evaporation of the water, and to form a ledge on which moisture can rest. When a boiler forms one of a battery, and is kept standing for a long interval, the top of the boiler is liable to pitting. Steam finds its way into it, and condenses on the roof, causing bad pitting there. Perfectly pure water containing no air does no harm, and steam alone will not cause pitting unless it gets a supply of air. The Loch Katrine water of Glasgow, which causes pitting on clean boilers, contains much gas. MM. Scheurer-Kestner and Meunier-Dolfus inclosed a polished iron bar in a natural water containing much oxygen, and no lime salts. The bar gradually rusted, but the corrosion ceased when the oxygen was used up. The bar was then removed, repolished, and put back, after which it remained perfectly bright. Repeating the experiment with water containing lime, the rusting was much less complete, the lime salts forming a protective layer on the iron, but on polishing this off corrosion recommenced. In distilled water the bar remained quite bright. The corrosion is much more rapid if the water contains carbonic acid gas as well as oxygen. In this case a voltaic action takes place. The rust first formed is electro-positive to the iron, which then dissolves away, decomposing the water. It is for this reason, that in cases of pitting it is essential that all traces of the iron peroxide should be cleaned from the metal, or the rusting will continue.

— *Engineering.*

WHEN Conductor Bray of the south-bound train to New York made his rounds after leaving Hartford yesterday, he scrutinized very carefully and perhaps more than half doubtingly, a ticket offered him by Vice-President Allen of the Hartford Steam Boiler Inspection and Insurance Company. It bore the stamp of J. Scrugham Quin, October 1, 1875, and was sold by him to a prominent business man of this city, lately deceased. For some reason he did not use it, and it was found among his papers after his death. It was redeemed by the railroad company, who sold it to Mr. Allen. It bore the number 2,702, and was apparently as crisp and bright as on the day of its first issue. —*Hartford Courant.*

The Ventilation of the House of Representatives.

In a recent issue of THE LOCOMOTIVE we quoted, from a daily paper, certain figures relative to the ventilation of the National House of Representatives. Through the courtesy of Mr. Henry Adams we have since been provided with a copy of the reports on this subject that were submitted to the House Committee by himself and by Dr. J. J. Kinyoun. These reports contain a considerable amount of interesting matter.

"The air used for ventilating the basement and upper floors of the south wing of the U. S. Capitol, and also a part of the terrace rooms belonging to this wing, is taken from the Capitol grounds west of the building. The intake for the air consists of a tower, open at the top, and about 21 feet high, above the surrounding grounds. It stands about 390 feet in a west-southwesterly direction from the northwest corner of the south wing of the Capitol, and its surroundings are such that the condition of the air drawn in through it is quite satisfactory — as perfect, in fact, as could be desired, or be had anywhere about the Capitol." Doubtless many of our readers will remember this tower, which is apparently intended purely as an ornament to the grounds.

It appears from Mr. Adams' report, that the air used in ventilating the House is handled by one 16-foot fan, driven by a direct connected steam engine, and running ordinarily at a speed of about 55 revolutions a minute. This corresponds to a delivery of about 2,400,000 cubic feet per hour. The air supplied to the floor of the House enters through gratings, which "form easy, accessible places to be used as cuspidors, and as convenient openings through which pieces of paper, cigar stumps, remnants of fruit, lint from carpets, etc., are thrown or swept."

Dr. Kinyoun adds, "What is said of the gratings can also be applied to the carpet, which is not in the best condition. In some places it is saturated with tobacco expectoration, a condition which tends to make it none the less odorous. The same condition exists in the galleries, although to a lesser degree than on the floor of the Hall, except in the gallery opposite the Speaker's desk, where it is worse, odors of tobacco and other things being always prominent. When the galleries are filled, the main gallery particularly, the odors above referred to are augmented by others emanating from those persons who are never in the state next to godliness — the vagabonds who congregate in this gallery during the winter months for the sole purpose of keeping warm." The doctor also says that "the dirt that accumulates on the floor is of a complex nature, both as to the materials that compose it and the odors that it evolves. The sweepings collected from time to time have shown on examination a little of everything — dirt from the street, dust, tobacco, food, fruits, nuts, paper, expectoration, and bacteria. This filth is subject to the air current, which acts as a distilling process, setting free the complex odors, holding the matters in suspension, and carrying them up into the Hall."

How would it do to turn the hose on our august legislators ?

Peruvian Trepanning.

A recent article under this heading appeared in the *Scientific American Supplement*, and we confess that since reading it we have conceived a particular respect for Aztec surgery. Trepanning, or "trephining," consists in the removal of a button of bone from the skull for the purpose of removing some obstruction that interferes with the normal activity of the brain, or for gaining access to the cranial cavity for some other purpose. The operation is an old one in Europe, but until reading the article referred to, we were not aware that it had been extensively and successfully practiced by the Peruvians before the advent of the Spaniards. "The ancient Peruvians," says Mr. Hovey, "seem to have been adepts in surgery, as in everything else. They excelled in agriculture, mining, milling, weaving, and engineering. Their cyclopean ruins are marvels of architectural skill. Indeed, in many respects they surpassed their Spanish conquerors. Hence we are not surprised to be told that they included a knowledge of the art of trepanning among their accomplishments. Several single specimens of trepanned skulls have been sent from time to time to American and European museums; but the Muniz collection, exhibited at the World's Congress of Anthropology, and now in the custody of the Bureau of American Ethnology, is the most remarkable of its kind. The entire collection includes about one thousand skulls exhumed from the vicinity of Cuzco, Huarochiri, Tarma, Pachacamac, and Canete. They belong to Senor Manuel Antonio Muniz, M.D., Surgeon-general of the Peruvian army, and will shortly be returned to the Peruvian museum at Lima. Nineteen of these skulls are especially interesting as showing the methods and results of primitive trepanning." Mr. Hovey presents eight excellent photo engravings of trepanned skulls, and says that "what first strikes our attention is the fact that no signs are seen of the use of metallic instruments, which agrees with the theory that this trepanning was pre-historic. In some instances the cranial incisions were narrow, long, and straight, usually at right angles with one another. The cutting was what might have been done by an arrow point held vertically and drawn backward and forward, making a groove deeper in the middle than at the extremities. In other cases the direction of the cutting was constantly changed, so as to saw out an elliptical piece from the skull, the rough tool-marks being afterwards scraped smooth. In still other cases there appears to have been no cutting nor sawing, the entire process having been effected by scraping, and the opening thus made being circular. Occasionally the operation may have been post mortem, as in one skull where twenty distinct incisions are to be counted. If ante-mortem, the individual certainly could not have survived such heroic treatment. The supposition is, that in these cases the purpose was not surgical, but was merely to obtain a bone button to be worn as a trophy or a charm. Most of the nineteen trepanned skulls, however, show signs of a surgical or thaumaturgic purpose. There are indications of a subsequent sloughing of the bone, or else of reparative growth, either of which would prove the operation to have been ante-mortem. One skull was trepanned three times, the subject surviving two operations, but succumbing to the third, which cut through two of the sutures. In several cases the partial or complete absorption of the plates and spongy substance between them is an evidence of the survival of the patient. In one skull the bone was plainly diseased, and suggests the possibility that the orifices were caused by decay, instead of artificially. In others the signs of previous cranial fracture are evident. In the head of a mummy the skull had been fractured by a blow, after which the scalp had been laid open and trepanning begun by three incisions, with the object of removing the broken part, but discontinued on account of the death of the patient."

In one case illustrated by Mr. Hovey, the skull was small and thin, and was undoubtedly that of a young woman. Some distance from the trepanning there is a depression in the skull, which was probably produced by a blow received a considerable time before the operation. It is thought likely that this depression may have induced the diseased condition for the cure of which the trepanning was performed. At all events it is certain that operations to relieve the patient were performed successively until the perforations merged into one very large opening, four inches long by more than one inch wide. "This enormous aperture was covered by a silver plate found in the mummy case with the remains. The marks of its seat in the skull are distinctly visible, but the plate itself has not been sent to this country, being still in the possession of Dr. Muniz, who vouches for the facts. There is every indication that the patient long survived the series of operations performed, making this ancient Peruvian case worthy of being mentioned along with the historical record of the Count of Nassau's being trepanned twenty-seven times during King William's wars.

"The results of modern trephining, with the improved instruments, are generally anything but encouraging. Promptness is demanded in beginning, and great caution in proceeding; hence, the opinion prevails that greater success attends private practice than those cases where there is delay in getting the patient to the hospital, and a subsequent expedition arising from the multiplied claims on the surgeon's attention. According to Gross, trephining is nearly always fatal in the hospitals of Paris and Vienna. The proportion of recoveries in the hospitals of London, Dublin, Edinburgh, and other large cities of Great Britain is officially reported as only one in four cases. A similar report is made by the New York hospitals, where it is said that eleven in forty-five recover. This makes it remarkable, that in the Muniz collection, eight out of the nineteen individuals whose skulls were trepanned evidently survived one or more operations. Taken as a whole this unique collection is regarded by the Bureau of Ethnology as 'by far the largest and most instructive assemblage of specimens of primitive trepanning thus far brought together, and as of special note in that it demonstrates certain points that have been heretofore obscure.' It is not denied that the operations may have been partly thaumaturgic — *i. e.*, for the expulsion of evil spirits — but the indications are that there was also a degree of intelligent surgery adapted to remedy cranial fractures, and also to relieve certain diseases of the brain."

"A Remedy for Education."

Under this startling title, a writer in the *New Science Review* presents many thoughts and suggestions that should be useful to those who wish to improve our present educational system. "There are two great things that education should do for the individual," he says; "it should train his senses, and teach him to think. Education, as we know it to-day, does not truly do either; it gives the individual only a vast accumulation of facts, unclassified, undigested, and seen in no true relations. Like seeds kept in a box, they may be retained, but they do not grow. For years the mind is filled with facts that the mind is not trained to digest. To the physical body food is of value only when it is digested. So it is in the mind, with mental food; but if digestion were made continuous, perfect, and ever equal to the supply of food, overfeeding in either mind or body would be impossible. But in the education of to-day the digestion is not equal to the feeding.

"The greatest educational need of the individual is a trained mind — a mind that is ready on the instant — not the next day. With most persons the intellectual brilliancy, the proper thing to say, comes as an after-thought. An after-thought is but a beautiful possibility designed to fit a lost opportunity. It is no more helpful to a man than a flattering epitaph on his tombstone. With most persons this wit is like a night telegram,— it is not delivered until the next morning. Man expects his hand to be instantly ready to perform any motion of which it is capable; but he is resigned if his mind does not act quickly. He says that readiness is born with people; it cannot be acquired. If a man's heart, lungs, or stomach are weak, he consults specialists, and never gives up until he obtains relief. But if he cannot remember names or faces; if he is subject to that intellectual remorse known as after-thought; if he has no eye for color, or taste for music; if he has no command of language; if there is lack of power in any respect in his mind, he is perfectly resigned, and says, 'I am as God made me, and so I must remain.' When man fails he always does this. He says, 'I am as God made me;' but when he succeeds, he proudly proclaims himself a 'self-made man.' It is not necessary to submit to any mental weakness. Training will do even more for the mind than for the body."

Mr. Jordan's entire article is well worth perusal, and we regret that we cannot quote it in full. His method for the study of English, for example, is superior to anything that we have seen in the schools and colleges. "Constant training in *words*," he says, "is a vital part of mental training. Words are but symbols for mental images. . . . . There can be no clear expression if there is not clear thinking. One great failure in our education is that there is too much memorizing of mere words, instead of memorizing of mental images or pictures that these words call forth. Words should be looked upon as living things; to be studied in themselves, in all their forms and phases, rather than merely studied about. We should have laboratory work in words. Mere study of synonyms from books will do but little real good; the words must be studied in life. I have found classes intensely interested and quickened for an hour or more in the study of a few lines of newspaper writing; perhaps but a criticism of some famous man of the day. It was studied word for word. If any word was adjudged strong or fitting, the reason why it was fitting in that situation was discovered; if it was weak, it what respect it was weak. If it meant more or less than the thought required; if it suggested an association or an element not in harmony, another word was substituted. In this was something higher than mere dogmatic, individual criticism; for be the word good or bad the choice must be justified. The critical and the imaginative faculties of mind were trained together; for every substitution of a new word was an appeal to the imagination sustained by the judgment. Thus, the ear became wondrously quick to perceive the force of a word, its music, its fitness. Words of color were studied; words of size, and number, and form; words expressing the extremes of ideas; words expressing differing degrees of intensity of the same quality; the power of short words; onomatopes; words of every class, looked at from every point of view. . . . We have many teachers in our schools, and professors in our colleges, who value words, and seek to teach in this spirit, so far as the rigidity of the system will permit; but this is not enough. This study of words is so vital an element in the training of the mind that it should be begun in the very earliest classes, and never be lost sight of in the whole school and college training of the individual. Compositions are written by the pupils, and returned to them with a few red ink interlineations and corrections of mis-spelled words, mispunctuation, wrong capitalization, or errors in syntax, and but the occasional substitution of a better word. One hour's study of words before a class, from any one of these compositions, would be worth more than a whole term of the usual work."

Incorporated 1866.

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The Locomotive.

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The Shamokin Explosion.

Our readers are doubtless familiar with the general facts of the tremendous boiler explosion that took place in the outskirts of the town of Shamokin, Pa., on October 11th. No explosion approaching this one in magnitude has occurred in this country, and

SITE OF THE SHAMOKIN EXPLOSION.

hence it attracted wide attention, and was described rather fully (though somewhat inaccurately) in the daily papers. The loss of life at Shamokin was comparatively small. Many a less notable explosion has had a larger death list, but so far as the number of boilers involved is concerned, the present disaster is without a parallel. The great boiler explosion at Friedenshütte, in Upper Silesia, on July 25, 1887, approaches it more nearly than any other, in this respect.* In the Friedenshütte explosion twenty-two boilers (four of which were empty) burst simultaneously. Three firemen were killed instantly, and nine other men were injured so badly that they died three days later. In addition to these, thirty men and women were more or less severely injured.

With regard to the explosion at Shamokin we may say, that the destruction was so general and so complete that it is difficult to find a satisfactory explanation of it. If the boilers had been insured, we should have had an accurate knowledge of them which would, undoubtedly, have been of great service ; but in the absence of such definite knowledge, we cannot say positively what the cause of the disaster was. One of our most experienced men visited the scene of the explosion shortly after it occurred, and we present the following extracts from his report:

"When I reached the site of the Henry Clay colliery the ground was pretty well cleared up, but I managed to see a good many broken sections of the boilers, most of them partly buried in the culm banks with the fractured ends projecting upwards, and also many broken steam and water pipes, steam and water valves, fire fronts, and beams for supporting the boilers. I also made numerous enquiries from employes who were present both before and after the accident ; but their statements were so conflicting that I am in doubt as to the correctness of any of them. However, I will give you the facts as I have obtained them. There were thirty-six plain cylindrical boilers, each 34" in diameter and about 44 feet long outside of the heads, the heads themselves being of cast-iron, flat or nearly so, and about two inches thick. The sheets were single riveted, and varied in thickness from .26" to $\frac{5}{16}$". I was informed that there were six batteries, with six boilers in each. The individual batteries were further separated by longitudinal division walls whose thickness I could not ascertain, into groups of three boilers each, in such a manner that in every case three boilers were set over one fire, and connected at the front and rear and top and bottom of the heads by cast-iron water and steam pipes 3" in diameter. Each sub-battery of three was also provided with a cast steam pipe, 12" in diameter and about 8 feet long, with $3\frac{1}{2}$" flanged outlets that connected with 6" cast-iron nozzles riveted to the center sheets of the respective boilers, and also with two 4" flanged outlets, on top, for safety-valves. There were two $3\frac{1}{2}$" safety-valves to each sub-battery, or four such valves to each battery of six boilers. In addition to these openings in the steam pipes that I have described, there was, in each one, a 4" outlet on the front side, and to this was connected a 4" pipe about 5 feet long, at the end of which was a 4" tee-shaped stop-valve. The stop-valves were connected to a 12" cast-iron pipe, built up of eight-foot lengths, and extending across the entire battery of 36 boilers. At the center of this main pipe there was a 12" cast-iron tee, to which was connected a 10" wrought-iron pipe, which led down to the breaker, and from which the pumps were also supplied.

"On the top of each boiler were riveted cast-iron flanged hangers with cored openings for hanger bolts and cotters; and two heavy cast-iron beams with cored bolt holes extended across each nest of three boilers, some $10\frac{1}{2}$ or 11 feet from either end, the boilers being suspended from them by hangers. The feed and blow connections were attached, in every case, to the bottom of the shell, at the rear end. I saw some feed-valves, but no checks; and I am not sure that there were any checks. Pumps were used to supply the boilers, and there were also heaters, though I did not find out what kind of heaters they had. Ninety to ninety-five pounds of steam were usually carried, and sometimes the pressure was up to 120 pounds. [Assuming the iron plates of the

* The Friedenshütte explosion is described and illustrated in THE LOCOMOTIVE for June, 1888.

shell to have a strength of 50,000 pounds per square inch, and taking the efficiency of the longitudinal, single-riveted joints at 50 per cent., which is probably about the right figure, it is easily seen that at 120 pounds pressure the factor of safety of the shell was only about *three.*—Ed.] The explosion occurred about 7.30 A. M. on the morning of October 11th, shortly after the day shift of firemen came on. In this shift there were four men in addition to the water tender. All five were killed instantly, and another person — a boy who was at work near the culm tipple in front of the right-hand boiler — was badly scalded and injured about the hips, so that he died a day or two afterwards.

General View of the Ruins.

Several others were injured, two of them rather seriously; they are now in the hospital, and are expected to recover.

"In looking over the remaining parts of the boilers I saw there, I noticed that most of them broke through the line of rivet holes of the small courses in front of the steam outlets, nearly in two halves. Others broke on the small courses back of the front hangers. I saw one piece with the front course and front head, and another with five courses and a front head. I also noticed a part of two courses torn in shreds and badly battered up, but I am not sure whether this was a piece of a boiler or of one of the iron stacks, as it was covered with mud and blackened with coal dust.

had been on the night shift, that he had been home only a short time when he heard the noise, and that it seemed to him 'like a pack of fire-crackers going off, only not so loud, more like squibs.' He said 18 boilers on the right and nine on the extreme left, had blown up, leaving intact a battery of six, which were on the left-hand side of the center, while three other boilers adjoining this battery were thrown down out of their beds. I am not sure that this was correct, as others told me that all nine were thrown down and scattered about, except that three of them fell together. It is possible that the latter version is the correct one, as the photograph that was taken on the day after the explosion shows three boilers lying together, side by side. The sections that were thrown backward landed on the hill in the rear of the original position of the boilers, and did no further damage. One piece was carried over a culm bank fully 100 feet high, and in its passage over the top of the bank it scooped out the culm to a depth of about one-third of its own diameter, landing in a valley on the other side. Another piece containing five courses was thrown across the valley to the northwest, and landed on the slush bank west of the breaker after a flight of about 500 yards. Another piece went through the upper corner of the breaker, about 500 feet away, slightly injuring a boy who was working there. Still another fragment went through a hoisting-engine house about 300 feet distant, cutting the cable and carrying out the side of a small house fifty feet below. I saw another piece about thirty feet long, with one head still in it, entirely buried under an ash bank except for about two feet of its length that was still uncovered. I was informed that this was a part of one of the exploded boilers, but I doubt it on account of its position, although the condition of the broken end is very similar to that of a number of other pieces.

"I have made some inquiries regarding the cause of this explosion, but thus far I have been unable to find anyone who is willing to express an opinion. It seems to me, however, that the iron in these boilers may have been greatly weakened by the vibrations and strains due to repeated expansion and contraction; for most of the breaks seem to have occurred at points most likely to be affected by such a cause. The iron in all these boilers is of very poor quality, but it is of about the same grade as is used in very many other boilers in the coal regions."

Inspectors' Report.

OCTOBER, 1894.

During this month our inspectors made 8,509 inspection trips, visited 18,024 boilers, inspected 6,556 both internally and externally, and subjected 747 to hydrostatic pressure. The whole number of defects reported reached 12,323, of which 910 were considered dangerous; 47 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	905	29
Cases of incrustation and scale,	1,930	71
Cases of internal grooving,	115	8
Cases of internal corrosion,	643	57
Cases of external corrosion,	832	54
Broken and loose braces and stays,	182	27
Settings defective,	333	34
Furnaces out of shape,	558	23

Nature of Defects.	Whole Number.	Dangerous.
Fractured plates,	326	38
Burned plates,	246	18
Blistered plates,	260	9
Cases of defective riveting,	1,545	31
Defective heads,	116	12
Serious leakage around tube ends,	2,375	240
Serious leakage at seams,	577	43
Defective water gauges,	436	76
Defective blow-offs,	168	52
Cases of deficiency of water,	17	6
Safety-valves overloaded,	51	18
Safety-valves defective in construction,	102	36
Pressure-gauges defective,	527	21
Boilers without pressure-gauges,	6	6
Unclassified defects,	73	1
Total,	12,323	910

Boiler Explosions.

OCTOBER, 1894.

(231.)— A boiler exploded, on September 29th, at Hodge's mill, near Puxico, Mo., killing two men named Johnson, one unknown man, and two boys named Lee and Dixon. [We received notice of this explosion too late to insert the account in its proper place in the September list.— ED.]

(232.)— On October 1st a boiler exploded in F. B. Woodbury's chair factory, in the town of Orwell, near Pulaski, N. Y. The boiler was blown through the building, crushing floors, walls, and machinery for a distance of 50 feet, and breaking a hole some 20 feet in diameter in the outer wall. Fred Hilton had one arm crushed between the wrist and elbow, making amputation necessary. Lewis Finster, Edward Stevens, and William Sparks were badly scalded and bruised, and Engineer Sheppard was slightly hurt.

(233.)— A boiler exploded, on October 2d, at Boyer & Caldwell's oil well, near Cooperstown, Pa. The boiler-house was torn to fragments, and boards and pieces of timber were scattered all about. Lemuel Hutchman, who was unloading tubing from a wagon near by, was blown fifty feet and probably fatally injured. Three of his ribs were broken and he was otherwise seriously injured. The boiler alighted in a field, three hundred yards from its original position.

(234.)— A boiler explosion occurred on October 3d at the Merchant's Cold Storage Company's plant, in San Francisco, Cal. The nipple under the rear of the boiler, where the feed and blow-off pipe were connected, gave way while the boiler was in use and under 95-pounds pressure. Peter Olsen, the engineer, was near the boiler at the time, and was scalded from head to foot. His throat and lungs were also fearfully burned, and he died after about three hours of intense suffering.

(235.)— The boiler furnishing motive power for the pile driver used in constructing the Louisville and Jeffersonville bridge, Louisville, Ky., exploded on October 4th.

Engineer W. G. Fitzhugh and a machinist named Samuel Fahringer were badly scalded. Five other men who were standing near by were also slightly burned.

(236.)—A boiler exploded, on October 4th, in Shultz's saw-mill, at Tygart Fork, near Parkersburg, W. Va. Frank Haley was instantly killed, George Shultz was scalded, bruised, and cut, about the face and head, so that he died shortly afterwards. Samuel Cook and Edward Sams were also scalded and burned so severely that they died within a day or two. Henry Mayhew was painfully injured, but will recover, and D. R. Sams was slightly bruised. The largest fragment of the exploded boiler was blown over the heads of about thirty school children, who were sitting on the log-carriage. It struck the ground some 250 feet away. The engine was also broken to pieces, and was found in the woods, 200 feet from its original position.

(237.)—On October 4th, a locomotive fell through a trestle on a lumber company's tram road, near Charleston, Mo. The concussion caused the boiler to explode, and Engineer Daniel Young and his fireman were fatally injured.

(238.)—A boiler exploded, on October 5th, in the Union Iron and Steel Company's "Siberia" mill, at Youngstown, Ohio. John Davis, a puddler's helper, was badly burned about the face, neck, and arms.

(239.)—On October 6th, a large boiler exploded at Mizell & Bros.' mills, King's Ferry, Fla. Engineer Fred Williams, Fireman Thomas Grant, George Noble, and Boston Taylor were frightfully scalded, and Noble and Grant are expected to die. The property loss was estimated at $5,000.

(240.)—Mr. M. B. Devane's cotton-gin, near Cecil, Ga., was destroyed on October 6th, together with its machinery and other fixtures, by a boiler explosion. Mr. James G. Futch was decapitated by a fragment of the boiler. Another piece of the boiler struck Mr. Nathan Devane, fracturing several of his ribs and perhaps injuring him internally. Two other men, whose names we have not learned, were severely scalded, and one man had his foot broken by a falling timber.

(241.)—On October 9th, a boiler exploded in L. C. Downtain's cotton-gin, at Eastland, Texas. Engineer W. D. Skelton was killed, and O. C. Scarborough, George Parker, and H. Y. Hill were injured.

(242.)—A small boiler exploded, on October 11th, near the Standard Oil Works, in Los Angeles, Cal. The roof of the building in which the boiler stood was blown about 250 feet into the air, and the contents of the building were scattered promiscuously about. Nobody was hurt. The boiler was used for supplying steam to a pump.

(243.)—A fearful boiler explosion occurred, on October 11th, at the Henry Clay shaft, at Shamokin, Pa. Twenty-seven boilers out of a battery of thirty-six exploded. The boiler-house was utterly demolished, and Thomas Carr, William Boyle, William Estick, and William McLaughlin were killed. J. J. Didian and John Flickensteine were also fatally burned, and died in a short time. William Cuimm, Peter Heck, and Dennis Brennan were badly scalded, and the shaft was filled with débris. The colliery is operated by the Philadelphia & Reading Coal and Iron Company, and was considered to be one of the best-equipped plants in the Shamokin district. The property loss is estimated at $100,000. Sixteen hundred men and boys were thrown out of employment. A further account of the explosion will be found on the first page of the present issue.

(244.)—The boiler of locomotive No. 126, of the Delaware, Lackawanna & Western railroad, exploded on October 12th, at Glen Ridge, N. J. The big engine turned a somersault in the air, landing upon the track with her cab-end forward and her wheels in the air. Elmer Cumming, the engineer, was pinned to the ground beneath the wreck of the locomotive, and was dead when released. The fireman, Charles Bareland, was fearfully injured, and died during the night.

(245.)— A boiler exploded, on October 12th, at Down's saw-mill, in Sims township, near Paris, Ill. The boiler was blown through the roof of the building in which it stood, and landed some distance away. Engineer John W. Young was badly scalded, but it is believed that he will recover.

(246.)— The boiler in Woodring's furniture factory, at Waverly, Iowa, exploded on October 12th, doing a considerable amount of damage. John Hinmon, the engineer, was badly scalded about the face, hands, and legs, but he will live. The boiler was a new one, having been in use only about a year.

(247.) —Word received from Sacramento, Cal., says that the crown-sheet of a locomotive blew out near Colfax, on October 15th. Engineer G. W. O'Neil had one leg broken, and Fireman Chinar was blown out of the cab and badly bruised.

(248.)— A boiler exploded on October 15th, at M. H. Keller's saw-mill, situated on Sugar Run, about fifteen miles from Bradford, Pa. George McAllister and Augustus Carlson were instantly killed, and William Dyer was injured so badly that he died a day or two later. George Lewis was also injured about the legs. The mill was entirely wrecked.

(249.)— A boiler in the Preetorius Lumber Company's mills, near New Madrid, Mo., exploded on October 15th. At the time of the explosion the only men present were James Holmes, the engineer, George Burton, the watchman, and Volney Burton, the watchman's brother. Volney Burton received a fracture of the skull, and died instantly. James Holmes was thrown over a pile of lumber, and was injured so badly that he lived only about a quarter of an hour. George Burton was scalded so fearfully that recovery is impossible. The boiler was torn into three parts, all of which landed more than 300 feet from the scene of the explosion. The property loss is estimated at $4,000.

(250.)— A heating boiler exploded in the basement of a tenement house in Grand Rapids, Mich., on October 16th, shattering the entire first floor of the building, and creating a panic on the upper floor, where William L. Sage and his family live. Mrs. Sage and her baby were thrown down, and the account says that both were "sadly blackened" by the dirt and soot that came up from the regions below. The family on the first floor had moved out a few days before, and it is probable that had that floor been occupied, somebody would have been killed. The day was pleasant and the boiler was running light ; but "had the weather been cold and the steam up to cold weather pitch, the whole building would undoubtedly have been wrecked, and several lives lost."

(251.)— A hot-water boiler exploded, on October 16th, in the basement of Charles H. Strong's residence, Erie, Pa. The kitchen was almost completely wrecked, and considerable damage was done to the dining-room overhead. The explosion occurred shortly before four o'clock in the morning, and nobody was hurt ; but the property loss is estimated at about $5,000.

(252.)— On October 17th a boiler exploded in Henry Waters' planing-mill, in Carey, Ohio. The north end of the mill was torn to atoms. Solomon Sterling, the engineer, was buried beneath the ruins, and when rescued it was found that one of his arms was broken, and that he was badly cut and bruised about the head and other parts of the body. It is also said that he was seriously injured internally. John Greno's leg was crushed, and amputation was necessary. Thomas Hart was blown out of a second-story window, but he alighted in a pile of sawdust and escaped injury. One fragment of the boiler, weighing about 1,000 pounds, was projected nearly horizontally, and after describing an erratic orbit in the course of which it demolished several fences, it came to rest about 500 feet from its starting-point.

(253.)— The boiler of an illicit still exploded in a tenement house in New York city, on October 18th, severely scalding John Jobesky and Paulina Bossuk and her infant daughter Jessie. The woman's husband, Hermann, supposed to be the owner and operator of the still, ran away after the explosion, leaving his wife and child crying for help. A dozen barrels of mash were found in the room. Revenue officers took charge of the still, together with the finished and unfinished liquor on hand. The still was only a block from the Madison street police station.

(254.)— A boiler exploded, on October 20th, in Charles Hoerlein's carpet-cleaning establishment, on Cottage Grove avenue, Chicago, doing considerable damage, but fortunately injuring no one.

(255.)— On October 21st, a small boiler used for heating water in Simon Brustman's bakery, Chicago, Ill., exploded, fatally injuring the proprietor, and severely scalding his son, Harry Brustman, and a workman named Lawrence Walters. The damage to property was slight.

(256.)— Clift's saw-mill, twelve miles north of Princeton, Ky., was wrecked by a boiler explosion on October 23d. The workmen were about the mill at the time, but they all marvelously escaped injury. One man was firing up at the time, and the blade of his shovel was torn away, leaving the handle in his hands. A crowd of women and children had just left the place.

(257.)— On October 24th a boiler in the M. B. M. Peacock grain elevator, at Markesan, Wis., ruptured along a joint, and Adolph Schubert, an employe, was severely but not fatally scalded. The brick-work of the setting was all blown down.

(258.)— A boiler exploded, on October 24th, on the tow-boat *Sam'l Little*, while she was lying at the foot of Central wharf, Boston, Mass. The damage was slight, and we did not learn of any personal injuries.

(259.)— On October 25th a boiler exploded in the Atlantic City laundry, Atlantic City, N. J. Nobody was injured.

(260.)— A slight boiler explosion in the power-house of the electric car system at Leavenworth, Kan., on October 25th, stopped the cars and left the city in darkness.

(261.)— Two boilers exploded, on October 26th, in C. H. Thomas' saw-mill, at Woodland, near Bainbridge, Ga. Crawford Hawkins was killed instantly, and Lewis Strickland and George Strickland were fatally injured. Archie Baker and two other men named Wimberly were also seriously scalded and otherwise injured.

(262.)— A boiler in the wool works of J. M. Rogers, Paterson, N. J., exploded on October 29th, carrying away a part of the building. Several of the employes were slightly injured.

(263.)— On October 30th a boiler exploded in A. T. Kreps' mill, in South Parkersburg, W. Va. John Kreps and Daniel Jones were instantly killed, and Benjamin

Mounts was badly bruised. Kreps was a son of the owner of the mill, and was running the boiler in the absence of the regular fireman. This explosion seems to have been due to the fact that there was a stop-valve between the boiler and the steam-gauge and safety-valve. The Parkersburg *Journal* says, "The boiler being red hot and no water in, why, of course it exploded when water was turned into it." We don't know how that was, but the existence of the deathly stop-valve seems to be quite enough to explain the explosion, especially as the valve was closed when found among the débris.

(264.)—The boiler at T. D. Linder's ginnery, two miles from Hartwell, Ga., exploded on October 31st. James Wilson and Edward Evans were killed instantly, and the account adds the horrible detail that the "bodies of the two men were gathered up in baskets." The engineer, also named Wilson, was badly scalded and bruised, and his physicians say that he cannot live.

A NATURAL gas explosion occurred in the electric light station at Oil City, Pa., on October 14th. No serious damage resulted, and nobody was injured.

A STEAM radiator in the Hatch Cutlery Works, at South Milwaukee, Wis., exploded on October 4th, partially wrecking the nickel-plating room. There was no loss of life, but Mr. W. B. Collins was somewhat injured.

A VIOLENT explosion occurred in the bottling works of Seth Butler, at Des Moines, Iowa, on October 10th. The steam pipe connecting a radiator with the boiler burst, and bottles, desks, and other office furniture were thrown about the room. The loss amounted to about $300.

WILLIAM MILLER, John Holstrom, and A. B. Sparrow were killed, on October 8th, by the bursting of a steam pipe in the Illinois Steel Works, at South Chicago. Thomas Dorsey, Oscar Wagner, Joseph Todhunter, and Peter Moxey were badly injured, and it is doubtful if they can recover. About forty other workmen were burned more or less severely.

THE youngest son of John Drumheller, of Blanchester, Ohio, was experimenting in his back yard, on October 13th, after the manner of Watt. He had improvised a steam engine and was trying to run it by means of a boiler whose fundamental ingredient was a tin fruit-can. The boiler exploded, scattering steam and hot water in all directions, and the boy was seriously scalded from head to foot. An elder brother, who was watching the experiment, was also slightly burned about the face.

A CURIOSITY in railroad building is the road running from Ismid, a harbor about 60 miles from Constantinople, to Angora, about 300 miles. The bridges, ties, telegraph poles, and rails are iron, most of which are of German manufacture. The bridges average about four to the mile, there being 1,200 of them, the longest having a stretch of 590 feet. In addition to these, there are 16 tunnels, the longest measuring 1,430 feet. This is the only railroad which penetrates the interior of Asiatic Turkey, the Smyrna lines being near the coast.—*Railway Review*.

The Locomotive.

HARTFORD, DECEMBER 15, 1894.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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ANOTHER year is gone; and may the new year be a happy one to all! The index and title-page for THE LOCOMOTIVE for 1894 are in preparation, and will be sent to those who have preserved their copies for binding. Bound volumes for the year will also be ready in January, and may be had at the usual price of one dollar each.

IN the course of an article on mosquitoes, quoted from *Insect Life* in a recent issue of the *Scientific American*, Mr. Howard Evarts Weed tells how he succeeded in freeing a certain locality of these troublesome pests by adding kerosene to the tanks of water in which observation showed that the mosquito-larvæ were developing. He adds, "I have also found that kerosene is a good article to use to prevent mosquitoes from annoying one when they are numerous. A little of it is smeared on the back of the hands and also upon the face. At first thought this would seem to be a disagreeable operation, but a trial of it will prove that it is not so in the least. It is quite effective in keeping the mosquitoes away, and it is certainly much better than the Florida method, which, I have been told, is to remain secreted under a large iron kettle, and with a hammer to clinch the bills of the mosquitoes as they are thrust through the kettle."

"Inspection Cheap" means "Cheap Inspection."

An esteemed foreign correspondent writes to THE LOCOMOTIVE as follows: "I could tell you some very funny stories about boiler 'inspection' as carried out by some companies in this country, the result of utterly incompetent men being employed in consequence of the low rate due to competition. I remember once being called on to advise about some boilers, and while I was carrying out a hydraulic test of one of them the 'inspector' of the company under whose charge they were turned up and stopped the whole thing. The test revealed a number of serious defects and led to my at once shutting down the boiler and having certain plates cut out; but the 'inspector' went off and wrote a special report certifying that he had made a satisfactory *thorough* inspection! When the plates I had condemned were cut out we found that the seams for an aggregate length of *fourteen feet* were cracked between the rivet holes, nearly through the plate; the solid metal left being nowhere over one-sixteenth of an inch thick!"

Of course all men are fallible, and the most experienced and thoroughly honest inspector may occasionally fail to detect a defect; but it is evident that such lapses will be reduced to a minimum by employing the best men that can be had. Care in the selection of inspectors is the first duty that an insurance company owes to its patrons. It is not always an easy one to fulfil, however, for a man may have handled boilers intelligently all his life, and yet make an extraordinarily poor inspector.

Concerning Earthquakes.

Buckle, in his *History of Civilization in England*, touches upon the rôle that earthquakes have played in the development of civilization in countries commonly subject to these disturbances, and calls attention particularly to the fact that the terror inspired by seismic phenomena does not diminish with their continued repetition, but rather increases. In this connection the following passage from an old number of the *Popular Science Monthly* may be of interest:

"'I must not omit to mention those prognostics which were derived from animals. They were observed in every place where the shocks were such as to be generally perceptible. Some minutes before the shocks were felt, oxen and cows began to bellow, sheep and goats bleated, and, rushing in confusion one on the other, tried to break the wicker-work of the folds; dogs howled terribly, geese and fowls were alarmed and made much noise; horses that were fastened in their stalls were greatly agitated, leaped up, and tried to break the halters with which they were attached to the mangers; those that were proceeding on the roads suddenly stopped, and snorted in a very strange way. The cats were frightened, and tried to conceal themselves, or their hair bristled up wildly. Rabbits and moles were seen to leave their holes; birds rose, as if scared, from the places on which they had alighted; and fish left the bottom of the sea and approached the shores, where at some places great numbers of them were taken. Even ants and reptiles abandoned, in clear daylight, their subterranean holes in great disorder, many hours before the shocks were felt. Large flights of locusts were seen creeping through the streets of Naples toward the sea the night before the earthquake. Winged ants took refuge during the darkness in the rooms of the houses. Some dogs, a few minutes before the first shock took place, awoke their sleeping masters, by barking and pulling them, as if they wished to warn them of the impending danger, and several persons were thus enabled to save themselves.' What it is, before the sound or shock of earthquake is felt, which warns both animals and human beings of the approach of some dreadful catastrophe threatening the very basis of their existence, no one, of course, can say."

The Early History of Crucible Steel.

It was in the immediate neighborhood of Sheffield, England, that the first successful process for the fusion of steel on a commercial scale was devised. The late Dr. Percy, a leading authority in general metallurgy, said: "Formerly, so far as I am aware, steel was never melted and cast after its production, and in only one instance (namely, in the case of Wootz steel) was it ever molten during its production. Indeed, by the founding and casting of steel after its production its heterogeneousness is remedied, and ingots of the metal can be produced of perfectly uniform composition throughout, and for the practical solution of this important problem we are indebted to Benjamin Huntsman of Sheffield."

As a recent journal appropriately remarked, "Huntsman's patient efforts, at last rewarded with success, entitle him to an elevated niche among the heroes of industry.

The invention of cast-steel was second in importance to no previous event in the world's history, unless it may have been the invention of printing."

Huntsman was born in 1704, his parents being natives of Holland, who came over and settled in England. He belonged to that sturdy religious persuasion, the Quaker body, which has done much for Great Britain, as it has for a large State in America, interested in the iron and steel manufacture. His character is shown by the fact that he would not allow any portrait to be taken of himself, and he refused an offer to be made a member of the Royal Society in 1750, when his fame had already begun to spread. . . .

In the early part of Huntsman's life, about 1740, there was one great drawback in connection with the development of Sheffield. All the materials used had to be imported from either Sweden or Germany. Blister or cement-steel was imported from those countries, or, in some cases, the material obtained was a raw puddled or natural steel. A considerable trade was also done with Newcastle-on-Tyne, where several combination furnaces were worked, probably because the Swedish bar-iron found its way there more readily, owing to the shipping facilities. Whether these latter furnaces existed when Huntsman first commenced his experiments is not very clear; but in 1774, M. Jars, a French expert who visited England in that year, remarked in his interesting *Voyages Metallurgiques*, "There are many manufacturers of iron and steel (cemented) at Newcastle-on-Tyne;" and it appears that a considerable quantity went to Sheffield. Huntsman, being a maker of watches and clocks, often experienced much inconvenience from the irregular quality of the imported blister-steel. For fine work of this class the utmost attention is essential to insure uniformity of production. He was then settled in Doncaster, and from reported proofs of his ingenuity it appears that he was already known as the "wise man" of the neighborhood. It is not surprising, therefore, to find that his active brain set to work to master the problem from the solution of which we are to-day reaping so great a benefit — the problem, namely, of producing cast-steel by fusion.

From a recent excellent paper by Mr. L. H. Holland, F.G.S., assistant superintendent of the geological survey of India, it would appear that Indian Wootz steel, usually found in conical ingots and made by the carburization of wrought-iron crucibles (so he states), has very likely been made in India for many centuries, especially in Trichinopoly. Nevertheless, Huntsman was very clearly the first to establish a fusion process on something like scientific lines, and to make it a practical and commercial success. Smiles, in his *Industrial Biography*, gives an interesting account of the discoverer, giving him full credit after very careful investigations. Moreover, M. Le Play, professor of metallurgy in the School of Mines at Paris, after carefully weighing all the evidence obtainable, stated that without doubt the credit of the invention belongs to Huntsman. Finally, a controversy was conducted in the London *Times*, some twenty-five years ago, and the discoverer, as we believe, was again fully vindicated.

Difficult as the problem must have been in the crude state of metallurgical knowledge at the time, Huntsman, having set his hand to the plow, would not turn back. The chief difficulty lay in obtaining a fire-clay that would enable him to make a vessel or crucible in which the bar-iron or cement-steel could be melted. At that time there was practically no knowledge as to the requisite chemical constituents of a fire-resisting material. There was uncertainty as to the character of the materials to be used in melting; melting appliances were imperfect; and there was difficulty in obtaining the most suitable fuels. These and other obstacles would have discouraged any but the stoutest heart. Mr. Frank Huntsman has informed me that evidences about the works were formerly abundant (and even quite recently some have been discovered) of the large number of experiments that had evidently been tried in the early stages of the process. Buried salamanders are not unknown in the present history of metallurgy, and those found in the works of Huntsman afford a proof that in the past, as at the present time, success usually came after many trials.

Huntsman's first experiments were made at Doncaster, a town eighteen miles from Sheffield, to which city he removed about the year 1740. Here his further experimental work was carried out at Handsworth, a suburb of the town. Finally he removed to Attercliffe, a manufacturing district forming a part of the city, and his works are still in existence, considerably altered and enlarged, but situated in the street known to this day as "Huntsman's Row." Within a few yards of the works is Benjamin Huntsman's house, where he lived until his death at the age of seventy-two, on June 21, 1776. His remains lie in the family vault in Attercliffe cemetery.

The following excellent account of the methods originally practiced in Sheffield about 1764 is given by M. Gabriel Jars, in his *Voyages Metallurgiques*, edited by his brother and published in 1774: "Blister-steel is rendered more perfect by the following operation: Ordinarily, scrap and cuttings from articles of steel are used. Furnaces of fire-clay are used, of similar design to those for brass castings. They are much smaller, however, and receive the air by an underground passage. At the mouth, which is square and at the surface of the ground, there is a hole through the wall, from which the chimney stack ascends. These furnaces contain only one large crucible, 9 to 10 inches high and 6 to 7 inches in diameter. The steel is put into the crucible with a flux, the composition of which is kept secret, and the crucible is placed upon a round brick, set upon the fire-bars. Coal, which has been reduced to coke, is placed around the crucible and the furnace is filled. Fire is then put to it, and at the same time the upper opening of the furnace is entirely closed with a brick door surrounded by a circle of iron. The flame goes through the pipe into the chimney. The crucible is five hours in the furnace before the steel is perfectly melted. Several operations follow. Square or octagonal molds, made of two pieces of cast-iron, are put the one against the other, and the steel is poured in at one extremity. I have seen ingots of this cast-steel which resemble pig-iron. This steel is worked under the hammer, as is done with blister-steel, but is heated less highly and with more precaution, because of its liability to break. The object of this operation is to make the steel so homogeneous that there may be no flaw, as perceived in that which comes from Germany, and this, it is said, can only be done by fusion. This steel is not extensively used; it is employed only where a fine polish is required. Of it are made the best razors, some knives, the finest steel chains, some watch springs, and small watchmakers' files."

That Sheffield can pre-eminently claim the title of "Steelopolis," not less from its modern development than from its long-standing and traditional associations with the early developments of the metallurgical industry of iron and steel, is shown in an interesting manner by a Sheffield directory published by Yale and Martin in 1787, about ten years after Huntsman's death. We find that there were then some half-dozen manufacturers of adzes and hammers; about 50 makers of edge tools; not less than 40 engaged in file making; over 300 in pen-knife, pocket-knife, and table-knife manufacture; at least 50 in razor making; close upon 100 in scissors; and some 60 or 70 in the manufacture of scythes, sickles, and shears. Many of these, no doubt, were small workers, rather than large concerns; but it will be seen that here was the center for a considerable employment of steel. It was this, no doubt, that induced Huntsman to settle in Sheffield. The advantageous environment also proved to be of the greatest assistance in the rapid development of Sheffield. For example, its excellent supply of very pure water (also a source of cheap power) was believed by some to be of special quality and efficacy in the hardening of steel. In these days of investigation, many of the old ideas on such subjects have been exploded, and probably there is nothing in Sheffield water that cannot be obtained elsewhere, at least from water showing upon analysis the same chemical composition. Yet not very long ago a considerable quantity of Sheffield was exported to America, for hardening purposes.—Abstract of an article by Mr. R. A. Hadfield, in *Cassier's Magazine* for November.

The Strength of Welds.

At the recent convention of the National Railroad Master Blacksmiths' Association, Mr. S. Uren, who has charge of the rolling mill and blacksmith shop of the Southern Pacific railway, read a valuable paper upon the subject of welding. He began with a statement of the importance of the blacksmith's work in ensuring safety in railway travel. Every important member of the engine has passed through the smith's hands, and the whole train is connected by one continuous chain of welded iron; the smith is personally responsible for any accident that may occur through his carelessness in permitting any imperfections to pass through his hands knowingly. It is often the case that smiths will hide a defective weld by carefully hammering over the defect. Under no circumstances should this be permitted. Mr. Uren went on to state that lap welding is the usual method adopted by smiths, and when it is practicable, in his opinion, it is the best. In many cases there is not enough care taken in preparing the parts to be welded. The scarfs should be as long as can be conveniently heated, never more than a 45-degree angle. The scarfed surfaces should be slightly convex, or "high," in the center, so that when the two pieces are laid together for welding, the center will take its bearing first, as it is absolutely necessary that the center of the bar should be welded first. Prior to making the scarfs, upset the bar back as far as it will be exposed to intense heat, for the purpose of lamination over the whole length of the heated surface, as it is imperative that the iron that has been near a welding heat should be as perfectly hammered as the welded part. After the preparation of the scarfing is complete, lay the two pieces carefully in a hollow fire, and bring to the proper heat. Before laying together be sure no foreign element has adhered to the scarfed surface. In laying together, the point of one scarf should just reach the heel of the other. The weight of the hammer used to weld the two pieces must be governed by the size of the bar, as the blow should be sufficient to affect the center of the metal. With this precaution a good weld will be secured. In many cases, in testing welds by breaking transversely, Mr. Uren has found good fibrous iron in the welded sections, and crystalline metal each side of the weld. The cause of this is improper treatment of the iron back of the weld, or improper upsetting where it was brought too near a welding heat. Wrought iron becomes disintegrated to a certain extent when brought to a high heat; consequently, if there is not sufficient metal back of the welded section to receive the necessary lamination to bring the disarranged molecules to their original position, the strength of the bar is impaired. "V" welding consists of a combination of butt and lap welding. The scarfs are formed by fitting the two pieces together at an angle of about 45 degrees. In preparing the scarfs, make the throat of the inside angle a little rounding, and the point of the outside angle to correspond. The scarfed surfaces should be a little convex across the surfaces, as in the lap weld, for the purpose of ensuring a perfect weld in the center of the bar. This method of welding is usually adopted where large pieces of iron are required to be welded. In all cases in this class of welding the throat should be welded first by being driven together with a heavy sledge hammer, applied at the end of the bar when brought to the proper heat,— before being taken out of the fire, if practicable. "Butt" welding is simple and the work is easily prepared for it by upsetting the ends, leaving the surfaces a little convex. This method of welding requires great care in bringing the two pieces to be welded to precisely the same heat and keeping the surfaces perfectly clean.

Mr. Uren made quite a number of tests to show the relative value of the different methods of welding, and, taking the averages with those previously determined for the same iron unwelded, he gave the following statement: All butt welds showed crystalline structures on fracture, owing to the upsetting of the fibre by the nature of the weld:—

TABLE OF THE AVERAGE RESULTS OF MR. UREN'S EXPERIMENTS.

Character of Metal.	Tensile Strength.	Relative Strength.	Elongation in 8 inches.	
			Per Cent.	Relative.
Unwelded, ...	52,078 lbs.	1.00	22.2	1.00
Lap welded, ...	47,575 "	.91	19.7	.89
V welded.	46,386 "	.94	18.8	.85
Butt welded, . . .	43,954 "	.84	8.3	.37

— *Practical Engineer.*

AMONG the November boiler explosions we note one that is particularly distressing. The gentleman owning the plant — whom we will call Mr. Brown — had been repeatedly solicited to insure his boiler, but had steadily declined to do so. He had a good engineer, he said, and a good boiler; and he didn't need insurance. Once, when our agent visited him, he was a little petulant, and his conversation was perhaps more emphatic than polite; but within a week of that day his boiler blew up and destroyed the entire plant. He felt differently about insurance after that, but when he had rebuilt his mill, and saw everything running in good shape once more, he changed his mind again and said "lightning never strikes twice in the same place." Last month the new boiler exploded with disastrous results, and Mr. Brown was himself among the killed.

DISCUSSING the window-smashing by the recent powder explosion in that city, the *Waterbury American* asks: "What made all of the broken windows fall out instead of in? Perhaps that is a simple problem, if you only know how to get at it. To the average spectator of Tuesday morning's wreck it is still a mystery. Some figure it out that the concussion first forced the windows in and that resistance of the confined air inside sent them back again with force enough to break them — as if the force of the rebound were greater than that of the original blow. Another theory presumes that the windows were drawn out by the rush of air towards the vacuum caused by the explosion. [!] This, however, does not account for the breaking of windows that faced away from the vacuum, nor for the fact that in some cases the broken windows were in the second and third stories while those on the ground floor of the same buildings were unharmed."—*Hartford Times.*

Incorporated 1866.

Charter Perpetual.

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BOILERS, BUILDINGS, AND MACHINERY.

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The Locomotive.

PUBLISHED BY THE

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.
HARTFORD, CONN.

NEW SERIES.

Vol. XVI.

HARTFORD, CONN.

1895.

INDEX TO VOL. XVI, NEW SERIES.

ARTICLES MARKED WITH A STAR (*) ARE ILLUSTRATED.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES — VOL. XVI. HARTFORD, CONN., JANUARY, 1895. No. 1.

Cracked Plates.

There are certain classes of defects in boilers that boiler owners know about, and endeavor to avoid. Among these are the deposit of sediment and scale, leakage around tube-ends and along riveted joints, and overloaded safety-valves. These defects rather force themselves on the attention of the owners; but there are many other kinds of defects that are not so obvious, though they may be fully as dangerous. Among these less patent defects are cracked plates.

Frequently cracks start from the edge of the plate, opposite a rivet hole, in the girth-joint that comes over the fire. Such cracks are often due to distress at the joint arising from an improper arrangement of the feed-pipe; for if the comparatively cold

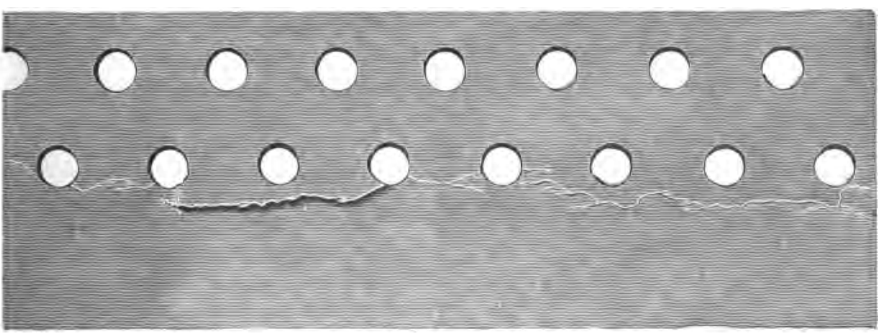


FIG. 1. — A CRACKED PLATE.

feed-water is discharged on or near the fire-sheet, it chills the shell in that vicinity, and produces a powerful local contraction of the metal, which is quite sufficient to start the joints, or, under some circumstances, to even crack the solid plate. But whatever the cause of the cracks, they are likely to first appear at the edge of one of the fire-sheets, and to extend gradually inward. Often they are stopped by running into the rivet-hole, and do not extend further. Frequently, however, they run past the rivet-hole, or cross it and extend into the sheet on the further side of it. It then becomes very important to check their further progress. This may often be done by drilling a small hole through the sheet at the very extremity of the crack. This hole may afterwards be filled with a rivet, or it may be tapped and filled with a screw plug.

Besides these fire-sheet cracks there are numerous other kinds, due to different causes. For example, the strength of a plate may be injured by overheating, or "burning," so as to develop a serious crack under the ordinary running conditions, without any assignable reason except that it has become too weak to withstand the strain that comes upon it in ordinary usage. Cracks are often discovered, too, along flanges that have been turned to too short a radius. Careless flanging is apt to start small cracks through the skin of the iron, and these frequently extend inward and eventually become dangerous. Incipient cracks on the inside of a boiler sometimes develop into deep grooves, the slight yielding of the shell, under varying pressure, opening up the interior of the metal to the corrosive action of the water. Defects of this kind usually occur along the edge of lap-joints, or near stay-bolts, where the shell is partially stiffened, and the buckling action of the plates more pronounced.

The accompanying wood-cut (Fig. 1) shows a crack due to a different cause, and it ought to carry with it a useful lesson. It represents a piece of plate that was cut from a boiler in active service, and which was believed to be in good condition. The boiler from which it was taken was 48 inches in diameter, with tubes 15 feet long; and the plates were of steel, ¼ of an inch thick. The piece of plate shown in the cut formed the edge of one of the sheets, where two sections of the shell were united by a longitudinal, double riveted lap-joint. It was taken from the upper part of the boiler, and was not exposed to the fire. It contained one well-marked crack extending completely through the plate, besides many other shorter ones running into one another in all sorts of ways, some of them extending through the plate, and others not quite through it. All these cracks were entirely covered by the inside lap of the joint, so that they could not be seen from the interior of the boiler; and on the outside, the boiler was covered at this point by a thick layer of non-conducting asbestos covering. We mention these points in order that the reader may understand how easy it would be to overlook this defect. Yet it would not be putting the case too strongly to say that although the boiler appeared to be in good condition, it was actually on the verge of explosion. For a considerable distance along the joint the strength of the plate was entirely destroyed; and at other places it was held together by the merest skin of metal, as was afterwards shown by breaking the plate across along the line of the cracks. The fractured area was almost entirely black, though bright spots were noticeable at intervals of two or three inches or so.

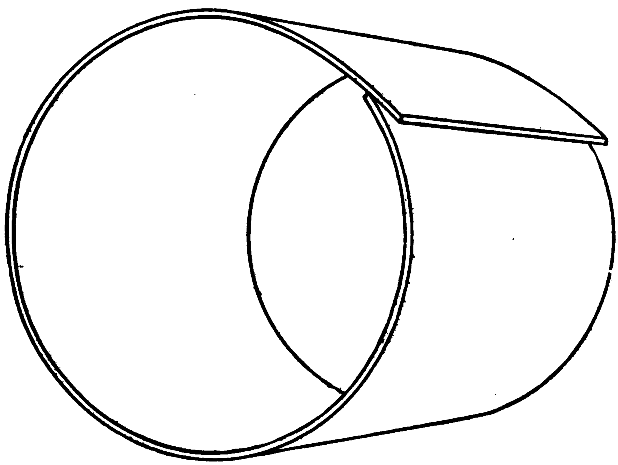
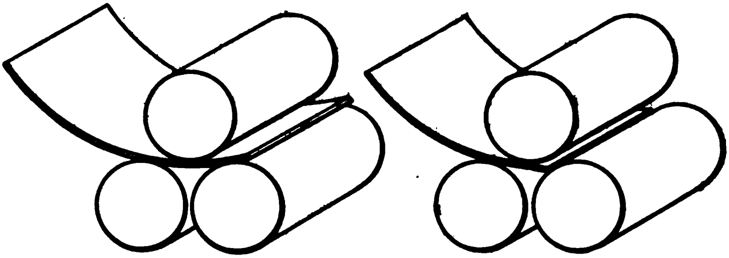


FIG. 2. —ILLUSTRATING THE "OFF-SET" OF THE LAP.

The cause of this defect will be sufficiently obvious to those who are familiar with the processes of boiler making. In rolling plates into the cylindrical form, preparatory to riveting them up into shells, it is customary to bend one end of the plate to what is judged to be the proper radius, by the use of the sledge-hammer. The plate is then run through the rolls and rolled into shape, the end that was previously bent being introduced first. When the plate has been rolled all but the last five or six inches the last end slips off of the first roll, and the rolls can no longer "grip" the sheet. The result is, that the last end of the sheet is not bent to the proper radius, but remains straight or nearly so. The shell (if rolled from one sheet) then looks something like Fig. 2, one end of it "standing off" from the rest of the shell. In order to make this action more evident we also present two diagrammatic views of a set of rolls in operation. In Fig. 3, the sheet has been rolled nearly to the end, and in Fig. 4 the end has passed over the first roll, the sheet is no longer "gripped," and the end has sprung back again so that it is nearly straight. In order to bring the outer lap to the proper curvature, it is customary for one man to hold a sledge against the projecting edge of the lap, while another workman strikes the shell on the inside. In this way the lap is bent down into place, and after the shell has been brought to conform with the "sweep" or templet, in every part, it is ready for riveting.

Now it will be seen that the treatment required for bringing the laps together in this manner is rather violent; and it follows that nothing but the best of materials will stand it without being greatly distressed and permanently weakened. Under the sledging oper-



Figs. 3 and 4.—Diagrams Illustrating the action of the Rolls.

ation the material is likely to be strained beyond its elastic limit, unless it possesses great ductility. The greatest strain on it comes on the outer lap, at or near the line where it touches the inner one in Fig. 2, or along one of the lines of rivet-holes, where the plate is weakened by the loss of material. We have no doubt that the cracks shown in Fig. 1 were started in this way, and that they afterwards crept into the plate gradually as the boiler yielded slightly under varying pressures, until they reached the highly dangerous state described above.

If the sledging were done while the sheet is hot, it would not be so objectionable; but the great majority of boiler-makers will not attempt to heat the plate before sledging the lap down, because when the sheets are hot they are apt to buckle out of shape, and give great trouble. If the sheets are to be sledged cold, the proper way to do it is to bend each end to the proper radius before beginning the operation of rolling. A convenient way to do this is to lay the ends of the sheet *over the upper roll*, and bring it down to the proper radius very gradually.

In the early days of steel boilers, before the manufacture of that material was understood as well as now, plates were much more apt to be injured by sledging than they are at present. Steel having a high tensile strength is almost certain to be deficient in ductility; and for this reason it is customary, in the specifications sent out from this office, to make the maximum allowable strength of plate 65,000 pounds to the square inch, when such plate is to be exposed to the fire. We also specify that the steel used shall show an elongation of twenty-five per cent. in a length of eight inches, that it shall show a reduction of area of not less than 56 per cent., and that its elastic limit shall be at least fifty per cent. of its ultimate strength. The plate should also be capable of being bent double and hammered, when either hot or cold, without showing cracks; and it is also desirable that it should stand this same test after being heated and quenched in water. Steel that possesses these qualities makes excellent boilers, and it will stand a great deal of abuse, in the boiler shop, without developing defects in after service.

In conclusion, we may say that cracked plates are not so uncommon as the average reader might suppose. This may be seen by glancing at our inspectors' reports, as published from month to month in THE LOCOMOTIVE. Thus we find that during the year 1892, our inspectors discovered no less than 2,646 plates that were cracked in one way or another, of which 658 were considered to be dangerous. During 1893 the number of plates classified as "fractured" was 3,532, and of these 640 were reported to be dangerous.

[This article is reprinted, with some slight changes, from THE LOCOMOTIVE for November, 1893, because the importance of the subject is so great that we desire to bring it before the public, and before our own inspectors, too, in as emphatic a manner as possible. Cracks along a row of rivets on the outer lap are especially dangerous because they can be overlooked so readily; and although the earlier grades of steel were more liable to them than those made at present, the danger is still very great, and should never be forgotten. Only a short time ago we found just such a crack as is shown in Fig. 1, *in a new boiler, not more than six months in use!* The case reported by our foreign correspondent on page 186 of THE LOCOMOTIVE for December, 1894, in which the aggregate length of the crack was fourteen feet, was also probably due to the cause we have outlined in the foregoing article.— ED.]

Inspectors' Report.

NOVEMBER, 1894.

During this month our inspectors made 7,681 inspection trips, visited 15,852 boilers, inspected 5,485 both internally and externally, and subjected 638 to hydrostatic pressure. The whole number of defects reported reached 10,592, of which 881 were considered dangerous; 53 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	826	37
Cases of incrustation and scale,	1,623	63
Cases of internal grooving,	160	6
Cases of internal corrosion,	516	58
Cases of external corrosion,	654	38
Broken and loose braces and stays,	147	51
Settings defective,	309	50
Furnaces out of shape,	439	12
Fractured plates,	318	54
Burned plates,	286	25
Blistered plates,	276	9
Cases of defective riveting,	1,383	83
Defective heads,	122	11
Serious leakage around tube ends,	1,823	164
Serious leakage at seams,	416	28
Defective water-gauges,	391	58
Defective blow-offs,	167	42
Cases of deficiency of water,	22	17
Safety-valves overloaded,	60	15
Safety-valves defective in construction,	87	26
Pressure-gauges defective,	473	29
Boilers without pressure-gauges,	2	2
Unclassified defects,	92	3
Total,	10,592	881

Boiler Explosions.

NOVEMBER, 1894.

(265.)— On October 26th a boiler exploded in the Ogden Coal Company's mine, at Ogden, near Boone, Ia. Mr. Emil Lewis was fatally injured.

(266.)— A boiler exploded at the Pittsburg & Tennessee Copper Company's plant, at Ducktown, near Knoxville, Tenn., on October 26th. Superintendent Carl Henrich was slightly injured. [The preceding explosions were received too late for insertion in the regular October list.— ED.]

(267.)— A slight boiler explosion occurred on November 2d in the Edison Electric Light plant in Cincinnati, O. Considerable damage resulted, and Daniel Blackburn was killed.

(268.)— On November 3d a boiler exploded in Foust's grain elevator at Grover Hill, near Van Wert, O. The son of the engineer, McDown, was killed, and the engineer himself and Mr. Foust were fatally injured. The building was completely wrecked.

(269.)— About November 5th a boiler exploded in the electric light plant in Urbana, O. The town was in darkness for several weeks.

(270.)— C. C. Rummel & Company's saw mill at Duff, Ind., was completely demolished by a boiler explosion on November 5th. Mr. Rummel was instantly killed, and his son and two other men were badly injured.

(271.)— Mr. Cato Gripon was seriously scalded on November 8th by a boiler explosion at Taylor's Bayou, on the Rice Farm of Mr. J. J. Burrell at Beaumont, Tex.

(272.)— A boiler exploded on November 8th at the Congo fire clay plant, at Toronto, O. The building was completely wrecked, and parts of it were blown 150 yards.

(273.)— A stationary boiler in the Wabash machine shops at Decatur, Ill., exploded on November 10th. Engineer Burrows was blown through a glass door and was seriously cut and scalded.

(274.)— On November 12th a blow-off pipe blew out of a boiler in the Empire Cordage Company's works at Champaign, Ill. Mr. A. Hughston was fatally scalded, and died a short time afterwards. Patrick Gillen and A. J. Freeman were also seriously injured.

(275.)— A slight boiler explosion in the Grape street school at Springfield, Mass., on November 12th, necessitated the closing of the school for a few days.

(276.)— A boiler exploded at the Charlestown Gas Company's plant, Charlestown, Mass., on November 13th. Thomas O'Malley was seriously burned about the arms and face, and received a concussion of the brain. He may recover.

(277.)— The boiler of locomotive No. 78 of the Concord & Montreal Railroad exploded on November 15th, near Nashua, N. H. The two front sheets of the boiler were blown off and the boiler tubes were twisted into fantastic shapes. Engineer F. W. Clifford escaped with slight injury, but Fireman N. F. Bean was severely scalded about the body.

(278.)— A mud drum exploded on November 15th at Muncie, Ind., in the muck bar mill. A shower of hot mud, boiling water, and steam was thrown along the length of the mill, and five men were scalded. John Gainer was terribly scalded over his hands, face, chest, and legs. He cannot recover. It is thought that the other men will not die.

(279.)— The boiler that supplies the steam that runs the pump at the Martsolf shaft on the McAntire & McKees lease of the James Bolen land at Spring City, Mo., exploded on November 15th, seriously injuring George and Charles Bailey and Daniel Reed. It was thought that Reed and George Bailey must die, but later advices say that they are improving. The boiler was blown over 100 feet from the engine-house, and the building was literally torn to kindling-wood.

(280.)— Three boilers exploded on November 15th at the Stockton colliery, near Hazelton, Pa. The boiler-house and an adjoining building were blown to pieces. Michael Keesha and James Hudaka were seriously injured. The middle boiler of the battery buried itself in a culm bank.

(281.)— One of the boilers at the electric power-house at Elwood, Ind., exploded on November 16th, demolishing the building and the adjacent street car barns. Twenty or more residences were also injured. The property loss to the power company is estimated at $60,000, and the damage to the residences will probably amount to $10,000 more. Norman Clark, the night engineer, was killed. Frank McDonald was buried in the ruins, but was not seriously injured.

(282.)— A boiler explosion occurred at the Stella sugar-house of Messrs. A. & S. R. Jacobs of Donaldsonville, La., on November 18th. No one was killed.

(283.)— A boiler exploded on November 19th on a pump-boat at Pittsburg, Pa. George Hullihan, Peter Berry, and James McClusky were painfully scalded. Hullihan will die, and it is doubtful if Berry recovers.

(284.)— On November 19th a boiler exploded in John Malcolm's cotton-gin at Cale, I. T. Charles Malone and William Robbins were killed, and Mrs. John Malcolm, wife of the owner of the gin, will die. Hal Morris, George Townsend, Alexander Jenkins, William Creel, and another man whose name we could not learn, were seriously injured.

(285.)— On November 20th a boiler exploded in Capt. Halliday's cotton-gin at Leland, Ark. The gin was a large one, and the damage to machinery, buildings, and cotton will probably reach $10,000.

(286.)— The crown sheet of a locomotive on a Chicago elevated railroad blew out on November 20th, and William Aldrich, the fireman, was injured.

(287.)— A boiler exploded on November 21st in the basement of J. R. Stout's barber shop, 603 West Taylor street, Chicago, Ill. P. H. Fleming, Geo. W. Holmes, Charles A. H. Miller, J. D. Murphy, James W. Sheridan, J. R. Stout, and Mrs. J. R. Stout were injured more or less seriously. Holmes is likely to die. The property loss to Mr. Stout is about $2,500, and the damage to the building, which was owned by Ferdinand Arndt, was about $800 more. The force of the explosion may be estimated from the fact that a passing street car was blown from the track.

(288.)— By the explosion of a boiler in a saw-mill at Monticello, near Orangeville, Ont., on November 21st, Robert McQuarrie and Alexander Darraugh were killed, and Otto Hendrickson and James Powers were seriously hurt. Two men named Walker and Cooper received lesser injuries. The mill was blown to atoms.

(289.)— A boiler exploded on November 22d in Liston Staley's mill, near Moulton, Ia. The mill was utterly destroyed and fragments of it were found a quarter of a mile away. Benjamin O'Neal was fearfully crushed and scalded and cannot recover.

(290.)— A boiler exploded on November 22d in the basement of the Center school at Uxbridge, Mass., under the floor of the primary department. The floor was completely torn up, and desks and seats were broken in pieces. Bricks were thrown through the floor as high as the ceiling. Thirty pupils were in the room at the time, and many of them were hurt in the panic which followed.

(291.)— A heating boiler exploded in Hartford, Conn., on November 23d, in the residence of a well-known citizen. The explosion occurred in the middle of the night, and nobody was injured, but a considerable amount of damage was done to bric-a-brac and other perishable articles in the room above.

(292.)— A boiler exploded about November 24th in Kelleher's mills at Bradford, Pa.

(293.)— On November 24th a boiler exploded at the Conway cotton-gin at Bryan, Tex. The boiler-room was wrecked, and Engineer Henderson lost his eyesight and was terribly scalded about the head.

(294.)— A boiler exploded on November 25th at the Burbeck coal bank, near Wadsworth, O. The attendants had left it only two minutes before, and nobody was injured.

(295.)— On November 26th a boiler exploded near Pottsville, Pa., in the Blackwood colliery, owned by the Lehigh Valley Coal Co. Fireman George Copeland was injured in the back, and George Sherock was badly hurt about the legs.

(296.)— By the explosion of a boiler in a mill at Danby, near Ithaca, N. Y., on November 26th, William Bierce and Fred Vanloon were killed, and Harry Beardsley and Fremont McFall were scalded so badly that they will probably not recover. Edward Martin and Charles Grant also received injuries that were painful, but not fatal. Both of Bierce's legs were blowh off.

(297.)— A boiler exploded on November 26th in the Loyal street school at Danville, Va. As the accident occurred about five o'clock in the morning nobody was hurt.

(298.)— By the explosion of a boiler in a power-house at Sharon, near Pittsburg, Pa., on November 26th, travel was suspended on the Chenango Valley electric railway. The damage was repaired in a day or two and traffic resumed.

(299.)— A heating boiler exploded on November 27th at the residence of Henry Withington in Lawrence, Mass. Parts of the house were wrecked, but no one was injured. The loss is estimated at $1,000.

(300.)— A boiler used to run a steam peanut roaster in Scranton, Pa., exploded on November 27th, and the flying peanuts and pieces of iron caused great destruction — especially the peanuts.

(301.)— Joseph Oliver was scalded to death on November 30th by the explosion of a boiler at Green Hill, near Bowling Green, Ky.

(302.)— On November 30th a fearful explosion occurred on the farm of Henry Leihold, near Cedar Rapids, Ia. A gang of men with a steam thresher were hulling clover, when the head of the boiler blew out. George Leihold was instantly killed.

(303.)— On November 30th the safety-valve casting on a boiler in the Briggs rolling-mill, in Findlay, Ohio, was blown bodily off. No person was injured, and the damage that was done was repaired next day.

Do Incandescent Lamps Start Fires?

A few very simple experiments that any one can make will answer this question in a fairly conclusive way and will furnish an interesting demonstration of the extent of incandescent lamp fire risks under certain conditions. Those who lack the opportunity to make the trials for themselves will find the results which they undoubtedly would have obtained in a report submitted a short time ago to John Lindsay, chief of the St. Louis fire department, by A. J. O'Reilly, supervisor of city lighting. The investigation which Mr. O'Reilly made was prompted by a recent fire in that city, supposed to have been started by an incandescent lamp lying against a couple of wooden poles, and his conclusions, which have since been borne out by similar tests repeated several times, are decidedly to the effect that an incandescent lamp may, under favorable circumstances, cause a fire.

Where the ignitable material was in a vertical position and the lighted lamp simply rested against it, Mr. O'Reilly found that in the case of white pine a spot one inch in diameter and having a light brown color appeared after about four hours. In the case of varnished oak, well seasoned, the varnish became blistered in three minutes and blackened in about fifteen minutes. The wood had the appearance of being charred at and near the point of contact, but was not ignited. A dry, white pine board began to smoke after forty minutes, but, through the breaking of the lamp, the test stopped at that point. With a lamp incased in two thicknesses of muslin, the latter commenced to scorch in one minute, in three minutes gave off considerable smoke, and at the end of six minutes, when the muslin cover was removed from the lamp and fresh air reached its interior, it burst into flames. Where a lamp was laid on inflammable material, the effect seemed to be more rapid, owing, probably, to the pressure exerted by the weight of the lamp. A newspaper was, in this way, carbonized in three minutes, and ignited in forty-five. The lamps used in the trials were all of sixteen-candle power, and the results satisfied Mr. Lindsay, as they will probably satisfy many others, that fires may sometimes be very properly ascribed to what has generally been regarded as an absolutely safe form of light. — *Cassier's Magazine.*

[The bulb of an incandescent lamp is ordinarily at such a temperature that one can just about bear its contact with the hand. If the radiation (and convection) of heat from the bulb is lessened in any way, say by covering the lamp with muslin, as suggested above, the temperature at once rises, and its ultimate value will depend upon how perfectly the heat is retained by the covering. It is a matter of common observation, especially in sick rooms, that it does not do to shade a portion of the apartment by throwing a dark cloth over the lamp; for even if the cloth does not take fire, the heat developed is likely to melt the rubber key by which the lamp is turned on and off. The ignition of cloth and wood by causes of this kind does not appear to be *directly* due to the high temperature produced by the lamp itself. The organic materials near the lamp are partially carbonized, the charcoal so formed condenses a considerable amount of air within its pores, and the heat given out by the air in its compression is added to that due to radiation from the lamp. By this double action the temperature may sometimes be raised to the point of ignition. A similar action may occur in wood-work near a stove-pipe or any other conductor for hot gases, and doubtless many of the so-called "mysterious fires" that originate near the heating apparatus of dwellings and other buildings can be ascribed to the same cause. The fact that freshly prepared charcoal can absorb (or "compress" within its pores) a considerable quantity of air or other gas is well known to all students of physics and chemistry, and many lecture-room experiments have been devised to illustrate the action. The medical fraternity recognize the same fact when they give dyspeptic patients charcoal tablets to absorb the gases formed in the stomach and intestines (although we question the efficacy of the remedy, because the charcoal becomes *wet*, as soon as it is swallowed). The affinity of charcoal for gases is probably due to the porous nature of the substance. *All* solids are known to carry a film of condensed air (or other gas) upon their surfaces, and the makers of Geissler's tubes and other high-vacuum apparatus are obliged to take special precautions to remove this film from the glass of which their tubes are made — otherwise an almost perfect vacuum would be sooner or later destroyed by the gradual "evaporation" of the layer of condensed gas on the inner surface of the apparatus. The condensation of gas upon solids is a *surface* phenomenon, and it is especially noticeable in porous bodies (such as charcoal), because their total surface is so enormous. Spongy platinum exhibits the same phenomenon in a marked degree, and if a jet of hydrogen gas be directed against a piece of it, the gas is absorbed so rapidly that the temperature of the platinum immediately rises to a red heat, and the jet of hydrogen is ignited. This ancient experiment is sometimes employed, by dabblers in science, for making "chemical cigar lighters." — ED.]

Injury to Boilers by Grease.

It has often been observed that small quantities of grease in combination with deposits lead to boiler accidents. This compound gets deposited on the plates, and the most violent water circulation is sometimes insufficient to remove it. The plates, in consequence, get overheated and accidents result. The introduction of grease inside the boiler should be avoided, especially where the water from the condenser is used for feeding the boiler, by the use of a sufficiently large feed-water filter. The Berlin Boiler Inspection Society had the following case brought under its notice: Two single-flued boilers, 4 feet 8 inches diameter, 23 feet long, flues 18 to 22 inches diameter, pressure 12 atmospheres, were used to generate steam for a 150-horse power engine with surface condenser. The installation had only been at work since July, 1893. A considerable portion of the flue of the left boiler had collapsed. This could not be attributed to shortness of water. On examination it was found that nearly all over the boiler a fatty brown slime had been deposited, which, being placed on a red-hot iron, burst into flame. The feed-water pump got its water from a large open tank over which a small filter was placed. The condensed water was led to this filter in order to have the grease removed. Unfortunately, the arrangements were so bad that a considerable portion of the grease found its way into the boiler. A similar case was recorded by Mr. Abel at the last meeting of the Markisch Society for Testing and Inspecting Steam Boilers. Four boilers, the feed water of which was heated by the exhaust steam from a Westinghouse engine, after being in use about six weeks, were so damaged that one boiler had to be completely removed; the other three had to receive extensive repairs. An examination of the boilers showed that the flues were covered with a deposit of fatty slime. An analysis of this showed that about 52 per cent. of it consisted of mineral oils and paraffine, and 27 per cent. of animal fat. It is strongly advised, therefore, that feed water shall always be filtered so as to remove any oils or grease. — *Scientific American.*

The Locomotive.

HARTFORD, JANUARY 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

As the heating apparatus in the gymnasium at Madison, Wis., was being tested under pressure for the first time (on November 9th), a violent explosion occurred, which shook the whole building. When the steam cleared away it was found that a large elbow had given way, a piece of which, after passing completely through a partition and tearing a door from its hinges, had passed along a hallway for a distance of 80 feet, and burst open the two heavily-bolted front doors. Workmen were standing near, but fortunately they all escaped injury.' If this account be true (we get it from a newspaper), we should like to know what kind of a pressure the Madison people use to "test" heating systems with.

The Shamokin Explosion.

The following extract from the *Scientific American* may be of interest to our readers, in connection with the great boiler explosion at Shamokin, Pa., which was discussed in our last issue :

At a recent meeting of the Engineers' Club, Philadelphia, Mr. John L. Gill, Jr., exhibited and explained a table showing the energy stored in boilers of different types, dimensions, and horse powers, and the height to which this energy could throw the boiler, with its weight of water, if allowed to act through an explosion. The explosion which occurred recently at Shamokin, Pa., in a plant of 36 boilers, arranged in nests of 3, whereby 27 of the boilers exploded and were thrown to a considerable distance from their original resting places, was possibly due to gas having collected under one or two of the boilers, and by its explosion breaking the branch connection to the main pipe, thereby causing others to explode; or it may have been occasioned by one set of boilers running out of water, the latter cause being the more probable [?]. Mr. Gill then explained, by means of the projecting lantern, a number of photographs which had been taken in the neighborhood on the day after the explosion. All of the boiler shells were broken circumferentially, and many of them had been thrown with such force that they had been embedded many feet in the side of a culm bank, some distance from the boiler house.

"As stated by Mr. Gill," said Mr. James Christie, "the boilers at Shamokin were horizontal cylinders, about 44 feet long, and were suspended by rods 11 feet from each end. Hence they were not only subjected to internal pressure, but also to unequal strains at the top and bottom, due to this manner of mounting, and the latter strains must have been very great. In long boilers like these there is also unequal strain, due to the differences in temperature between the bottom and top, the latter in this case being open to the air."

"When I was connected with the Edge Moor Iron Company," Mr. Henrik V. Loss said, "I remember to have made some experiments whereby we found that the differences between top and bottom strains in some cases might be as much as 5,800 pounds per square inch."

Mr. John Overn, chief boiler inspector for Philadelphia, referred to his examination of the remains of the Shamokin boilers as follows: "I examined the boilers at Shamokin on the day after the explosion and there was not a single case which showed any longitudinal strain. Each boiler shell was composed of 13 plates, and all but one of those which exploded broke in the section to which the suspension rods were attached. By the use of a blower the heat under the boiler cylinders was made very great while the top of the boilers was cool. After inspecting boilers for many years, I have noticed that there are comparatively few exploded because of low water. The disturbance at Shamokin, I think, was due to unequal elongation on opposite sides of the boiler shells, and to the very poor quality of iron used in their construction."

In *Cassier's Magazine* for January, an extract from which is given elsewhere in this issue, we find a series of articles of unusual interest — which is saying a great deal, for *Cassier's* is always bright, instructive, and artistic. There is nothing in it that will not well repay one for perusal. Mr. Nelson W. Perry's article entitled "The Feats of the Magnetic Girl Explained," although not strictly on an engineering subject, is nevertheless of interest to engineers, because it tends to clear up certain points in the mechanics of girls and chairs and broomsticks that are very confusing to the laity in general, and also, without doubt, to many of the mechanical profession. Mr. Perry says that the tricks of the so-called magnetic girls "seem, at first sight, to involve either the possession of superhuman strength, or else some occult power. As a matter of fact, however, they involve neither. The strangest part of them is that they are all within the ability of any of my readers to perform. Furthermore, it will be found that the very mechanical laws which these tricks appear to set at defiance are the ones upon which they depend for their success, and the chief reason why they have remained mysteries to those who have witnessed them is that they have not tried to repeat them themselves upon the first opportunity afforded." It is impossible to give a clear idea of the explanations that Mr. Perry offers in particular cases, without reproducing his illustrations; but he claims that all the tricks can be easily learned and performed, by anyone who is interested enough to try them.

"Kitchen Boiler Explosions."

We desire to acknowledge the little book on *Kitchen Boiler Explosions*, which the author, Mr. R. D. Munro, M.I.M.E., has kindly sent us. Mr. Munro is chief engineer to the Scottish Boiler Insurance and Engine Inspection Company, Limited, of Glasgow, Scotland, and is probably well-known to many of our readers through his book on *Steam Boilers*. His attention was specially directed to the explosion of kitchen boilers by the unusual succession of such accidents that occurred in England and Scotland during the early part of last January. (A list of thirty-eight of these explosions, which occurred during five days of cold weather, and which resulted in twelve deaths and in injuries to thirty-three persons, will be found in THE LOCOMOTIVE for March, 1894, on page 38.)

Many theories were put forth to account for these explosions, prominent among them being the usual low-water and "spheroidal state" hypotheses. Mr. Munro has undertaken to dispel the haze that enveloped the subject, and to find out the true cause of the explosions, by actual experiment. The general method of carrying out the experiments is described elsewhere in this issue, in an article taken from *Engineering*. It may be well to say that the kind of boiler contemplated by Mr. Munro is not very common in this country; it consists of a wrought-iron vessel with a capacity of from 10 to 20 gallons, so placed that the gases from the kitchen range pass under and around it on their way to the chimney flue. In this country the "water-front" is more frequently used, except where considerable quantities of very hot water are wanted; but as Mr. Munro's results have a direct bearing on boiler explosions in general, his book will undoubtedly be received by engineers in this country, as well as in England, as a valuable contribution to our knowledge of the larger and more destructive explosions that occur in boilers used for the generation of power. Of the conclusions reached by Mr. Munro, the following will be of special interest to our readers: "(1) The experiments prove that water will flow into a red-hot boiler although there is no free outlet, and, also, that a steam-pressure can be attained under such circumstances sufficient to cause rupture of the strongest boilers in use. (2) Although a very high steam-pressure may be generated in a red-hot boiler by the sudden injection of cold water, it was clearly demonstrated that a disaster cannot thus be produced, and that the internal pressure is dissipated almost instantaneously, upon the occurrence of a very small rupture or leakage. (3) It was also clear that an explosion, in the true sense of the word, cannot occur unless the boiler contains water as well as steam; and that the force of the explosion will be in proportion to the quantity and temperature of the water in the boiler immediately before rupture." Mr. Munro points out that a cubic foot of *water*, at a temperature equal to that of steam at 60 pounds pressure, has a total energy of 133 foot-tons, while the energy in a cubic foot of *steam* under the same conditions is only about one-third of one foot-ton. This fact, which has long been known, of course, fully accounts for the comparatively slight damage done by "low-water" explosions. "(4) The experiments, as a whole, proved conclusively that kitchen boiler explosions, like all other explosions, are due to simple and preventable causes. The outlets become blocked by ice or other obstruction, and, in the absence of a safety-valve, the pressure will rise more or less rapidly, according to the condition of the fire, until the strength of the boiler is exceeded, and explosion occurs."

Mr. Munro's little book is published by Charles Griffin & Co., Limited, of London.

Early Steam Heating.

The following letter appeared some time ago in the *Heating Engineer*, and will doubtless interest our readers, now that steam and hot-water systems are so common. The original, we believe, is in the possession of Mr. S. D. Tompkins, of Jersey City, N. J.

HARTFORD, Sept. 16, 1819.

ROGER M. SHERMAN, ESQ.,
Fairfield, Conn.,

DEAR SIR: — Yours of the 14th inst. lies before me, with the contents noted. You anticipate warming your dwelling-house with steam, and desire of me a particular account of the machinery necessary to the object. I shall be happy to give you all the information I possess on the subject, but at present decline doing it by writing, under the belief that it would not be done to your satisfaction or my own, even if accompanied with diagrams. Could I see you, sir, I have no doubt it would be in my power to give you more information in an hour than would be possible with the pen in two or three days. If, however, you have not business to call you hither, and still wish me to give a written description of the machinery, please to signify it, and it shall be done. It is perhaps proper for me here to state that my object in making the experiment last winter was simply to test the principle, whether steam can be advantageously used for heating rooms or not, and I am satisfied it can, under some if not all circumstances. My boiler was not of a kind, or set in a manner, to show the economy with which the thing may be done, but a boiler was afterwards constructed for a different application of steam which, I think, would clearly show that it is economical. The most successful experiments with which I am acquainted have been made in England, within a year or two, and apparently with great approbation. The differences of climate, I think, should be taken into consideration; it may be questioned whether it will answer as well in a climate so cold as ours, as in theirs; my experiments have not been such as to satisfy me entirely of the facts, but should say any desirable temperature may be obtained and kept up, even in our climate. If I am correct in my position, there cannot be a question but the advantages of using steam for warming rooms are so great as to demand its immediate introduction, to the exclusion of all other methods.

I am, sir, very respectfully yours,

LORENZO BULL.

Domestic Boiler Explosions.

When a fallacy is once promulgated, its vitality is something amazing. Owing to our mediæval system of education, the average middle-class man knows nothing of physics, and is thus not in a position to express an opinion on the accuracy of any of the many marvelous theories of the universe and all that in them is which are not infrequently thrust upon him by his daily paper.

The word electricity seems to have the same soothing effect on people of this class as the word Mesopotamia had for the old lady of the story. If a phenomenon is only said to be electrical, everything is considered to be explained, there being an inherent love of the marvelous in the run of mankind, which makes a straightforward and simple explanation much less to its taste than a more involved and mysterious one ; and when one of these occult explanations has once gained a fair degree of acceptance, its refutation may be compared to the labors of Sisyphus. The error may be clearly established by experiment, and for the moment its supporters are silenced or convinced; but a few months later the same old fallacy is again making the rounds of the papers, and the work of refutation has to be gone through again. One of the most persistent of these errors has been the theory that under certain conditions a safety-valve is useless on a boiler, owing to the alleged fact that it is possible to generate steam so quickly in an ordinary boiler that the valves would be unable to pass it and to prevent a very serious rise of pressure.

At the beginning of last year we republished a description of experiments made by the Manchester Steam Users' Association in 1867, which showed pretty conclusively that it was impossible to make a kitchen boiler explode by heating it to redness and then turning in cold water. No arrangements were, however, made to measure the pressure developed in these experiments, though it was known that it did not exceed 35 pounds per square inch, for which the safety-valve was loaded. In some later experiments made by the same association on a Lancashire boiler, this omission was made good, and in this instance it was found that on turning water on the top of the red-hot flues of the boiler a pressure of 27 pounds was reached. Naturally, it was not possible to heat any large proportion of a large Lancashire boiler to redness, and hence the red-hot surfaces were small in comparison with the cubic capacity of the boiler. It was, therefore, only to be expected that higher pressures would be developed if the experiments were repeated on a kitchen boiler, of which a large fraction of the whole surface could easily be made red-hot. This has now been done by Mr. R. D. Munro, the chief engineer to the Scottish Boiler Insurance and Engine Inspection Company, Limited, who has recently published a small volume,* giving the results of his experiments, which fully confirm the view that it is impossible to make a boiler "explode" by raising it to a red heat and turning cold water into it. It may be cracked, or a side may open, but no explosion in the proper sense of the term takes place, a very small aperture being sufficient to pass all the steam generated.

For the purpose of these experiments, a wrought-iron cylindrical shell, about 20 ft. long and 6 ft. 6 in. diameter, was prepared and erected with its axis vertical. The boiler to be tested was placed inside this, so as to prevent damage being done if an explosion did occur. A furnace was fitted inside this shell, and over it was placed the boiler to be tested. The boilers experimented upon were taken from the general stock of the different makers, and were fair samples of the ordinary domestic boiler. As a preliminary, a series of experiments were made to determine the size of safety-valve necessary to prevent a rise of pressure above that corresponding to the load on the valve. With a so-called "boot" boiler having a capacity of 14 gallons, and weighing 160 pounds, it was found that a dead-weight safety-valve, ½ in. in diameter, was capable of passing all the steam which it was possible to generate. In making the experiments with the "red-hot" boiler, it was found that a suitable safety-valve was again effective in preventing any serious rise of pressure, even when fully three-quarters of the whole surface of the boiler was raised to a red heat.

In the first of these experiments the safety-valve was loaded to 10 pounds, and, on turning on the water, the pressure due to the steam generated by the hot surfaces rose to 12 pounds, after which it fell again to 6 pounds, which was that due to the head of water in the supply pipe. The steam produced apparently cleared the boiler of water, but in a few seconds a second supply of water gained access to the boiler, sending the pressure up again to about 12 pounds, after which it fell below that due to the head. The "geyser" action again recurred, a larger supply of water reaching the plates than in the previous case, with the result that a pressure of 16 pounds was indicated on the maximum gauges.

In the second experiment the valve was loaded to 20 pounds, the head in the supply pipe being raised to 12 pounds per square inch; and in this case the boiler was made nearly white hot. On turning on the water, the pressure rose to 44 pounds, but then fell steadily, and at the end of 22 seconds was below the safety-valve load. On withdrawing the fire, the boiler was found considerably distorted, and a stay between the front and back plates was started. Very similar results were obtained on repeating the experiments on other boilers, and it was evident that the safety-valve, having a discharge area of but ⅕ square inch, was too small for the work, though, of course, the

* [See page 11 in this issue.—ED.]

conditions were much more unfavorable than they would be under any conceivable conditions in practice.

In the next series of experiments the boilers were fitted with a safety-valve of double the diameter, and, at the same time, the supply pipe was fitted with a non-return valve. The head causing flow into the boiler was 40 ft., or 18 pounds per square inch. With this arrangement, the pressure never rose above that due to the valve loading, the valve being able to pass easily all the steam generated. The pressure, however, always rose to the safety-valve load, and thus there is a difference between these experiments and those made by the Manchester Steam Users' Association on a Lancashire boiler, where the pressure never rose above 27 pounds per square inch. This, of course, is to be attributed to the much greater ratio which the heated surface bore to the internal volume.

To complete the experiments, the safety-valves were locked fast, and the boiler heated as before. On turning on the water, the pressure gradually rose up to a maximum of 118 pounds per square inch, when a part of the boiler gave way. There was, however, no explosion, a weld simply opening and letting the steam out quietly. The experiment was then repeated with a second boiler, which failed at 90 pounds per square inch. As before, there was no explosion, there being no reserve of highly heated water to keep up the pressure, as is necessary for a true explosion to occur. The boilers were not even shifted on their beds.

These experiments seem to prove conclusively that a boiler explosion cannot be caused by simply making the boiler red hot and turning water in. As Mr. Munro points out, in many towns a domestic boiler is quite as likely to run dry in summer as in winter, owing to the water supply being intermittent; but he has only found one case of a domestic boiler exploding in summer, and that was proved not to be due to shortness of water. In winter such explosions are frequent, and, in view of all the experiments which have now been made, it can hardly be doubted that they arise simply and solely from the plugging of the outlets, and that a suitable safety-valve forms a perfect guarantee against danger.— *Engineering.*

It was reported, a short time ago, that a boiler exploded in the rubber works at Akron, Ohio, about November 21st. According to the Akron *Democrat*, the rumor was untrue.

The United States revenue cutter *Rush*, which left San Francisco on November 28th, to determine, if possible, the fate of the missing ship *Ivanhoe*, returned to port next day in a disabled condition. She had not proceeded far on her way when one of her steam pipes burst and she was compelled to return for repairs.

Here is what the Bushnell (Ill.) *Democrat* says about a presumably esteemed contemporary: "The Warsaw *Pilot* is now run by wind, for sure. It was not so very long ago that the steam boiler in the office blew up, and all but blew the editor into another world, so that he has erected a wind-mill over the office, and runs his presses with that."

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES — VOL. XVI. HARTFORD, CONN., FEBRUARY, 1895. No. 2.

Boiler Settings.

The past few years have witnessed great changes in the practice of steam engineering, the sharp competition in all branches of business causing a decline in the prices of the products of mill and shop. This has made the cost of production a matter of great importance to the manufacturers, and one to which they have given much study. The cost of power, especially where steam is used, is a very important factor in the case, and it has received much attention; the general result being that the simple high pressure and condensing engines that were formerly considered good enough are being replaced by the best types of compound and triple-expansion condensing engines. Foreseeing

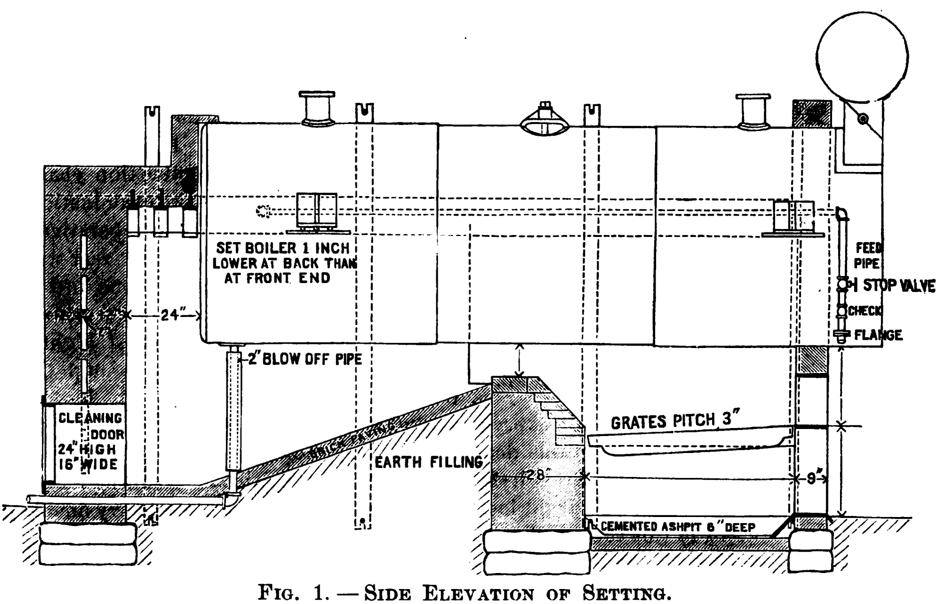

FIG. 1. — SIDE ELEVATION OF SETTING.

the necessity of better economy in the generation of steam, and of greater durability in the plants, the officers of the Hartford Steam Boiler Inspection and Insurance Company were led, after a careful study based upon years of experience, to prepare improved plans for the setting of externally fired boilers of the plain cylinder or tubular types, these being the prevailing forms of boiler that are used in this country. Increased capacity and economy seemed quite feasible with this class of boiler. The proportion of grate area to heating surface and to the tube area were carefully considered, as well as every other detail of the setting. The ratio of grate area to heating surface was considerably reduced in comparison with the ratio in general use at the time the company's setting was designed, and it is also less than is used by many designers at the present day. The width of the furnace in the settings advocated by this company is six inches less than the diameter of the boiler. Beginning just above the grate, the side walls batter at such angle as to make them 3″ clear of the boiler at the center, where the walls project inward and close against the boiler. This batter gives greater stability to the walls, and another special feature of it is, that it allows the heated gases to rise without impinging against the walls of the setting, and they flow away from the wall and distribute themselves evenly over the whole heating surface of the shell. The removal of soot and ash from the shells is also facilitated, and, moreover, it is found that these deposits do not form so readily when the walls are battered as they do when the walls are straight, and the space between them is correspondingly contracted. The batter also increases the volume of the combustion chamber, and allows of a more thorough mixing of the oxygen and furnace gases, the result being that complete combustion of the fuel is greatly facilitated. The bridge-wall slopes back from about four inches above the grate, at an angle of 40°, in order that the radiant heat from the fire may be diffused over a large portion of the boiler shell. The flame bed back of the bridge-wall slopes down to the level of the boiler-room floor. It is paved for easy cleaning, and the combustion chamber is large enough to make examinations and repairs to the boiler comparatively easy. The cleaning door in the rear wall is placed on a level with the flame bed in order that ashes may be readily removed, and as it is below the currents of highly-heated gases loss by radiation through the door is largely prevented. The loss or waste of heat from this cause is often very great and it has not generally received the attention it deserves. Another point that demands more attention than it usually receives, is the liability of *leakage* of cold air through the walls of the setting, with the resulting reduction of furnace temperature. To avoid loss of temperature from this cause heavy double walls are constructed in this company's settings, the outside walls of a battery having a two-inch air space between them. The division walls between two or more boilers should have a half-inch clear space between them, to allow free and independent expansion of the walls. With a solid wall and one or more boilers of the battery stopped, one side of the wall separating a boiler in use from another one out of use would be hot and greatly expanded, while the other side of it would be cool; the result being that the bonded or solid wall must necessarily be severely strained or injured, and the joints in the masonry quite probably broken by the unequal expansion. Excessive leakage of air is likely to follow. These criticisms apply to all solid-built boiler settings. While the heavy double walls are somewhat more expensive in first cost, the increased economy and capacity of the boilers, as well as the greater durability of the settings, fully warrant

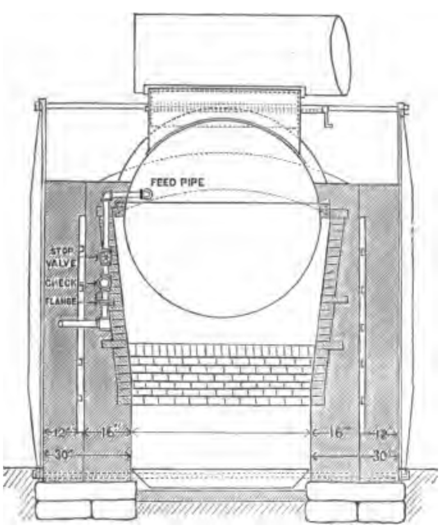

FIG. 2. — SECTION THROUGH FURNACE.

their construction. The results obtained in many large plants fully sustain this statement.

The exposed portions of the boiler shells above the settings are covered with plastic non-conducting covering 2½″ thick. This is much lighter than brick, is a better non-conductor, and does not exert a sensible thrust upon the setting walls as a brick arch does. If leaks occur along the joints of the covered part of the boiler, they are quickly noted by the discoloration of the covering, and may be stopped before injury from corrosion occurs. The illustrations give the general arrangement of the settings above described, in which it is desired to combine durability with simplicity in design and construction, and at the same time to obtain good results from the boilers, both in economy and in capacity. To obtain the maximum economy in the combustion of fuel, we should obtain the highest temperature possible in the furnace, and the lowest temperature in the chimney — that is, in the chimney we should have a temperature not greatly in excess of that due to the pressure carried in the boilers, and we should admit to the

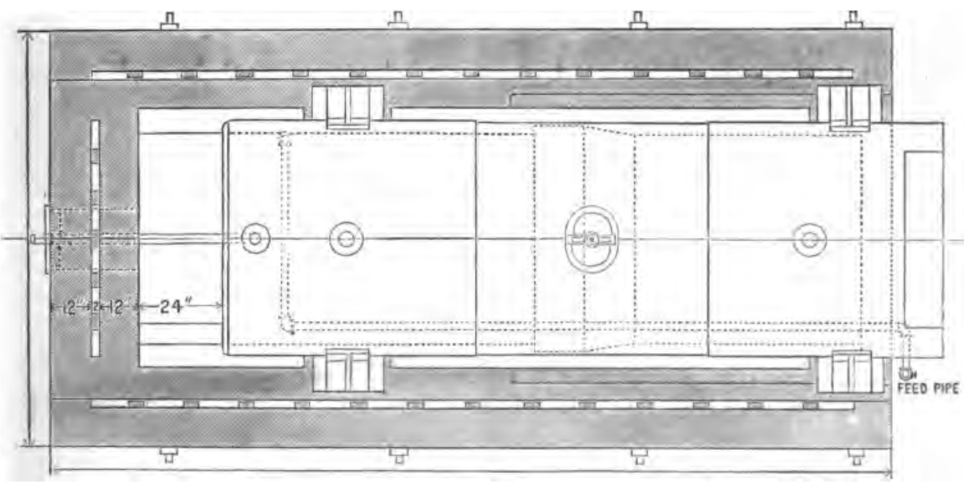

FIG. 3. — PLAN VIEW: SECTION THROUGH CENTER OF BOILER.

furnace the smallest quantity of air that will insure complete combustion of the fuel. With these ends in view, the relative proportions of grate area and heating surface, and of all other areas and proportions of the settings, have been placed within certain limits determined by experience. It is well known that the intensity of heat produced by the fuel varies with the rate of combustion; and if a temperature of 2,200° to 2,500° can be obtained in the furnace, and the heat can be distributed over the heating surfaces, and can be so absorbed that the chimney temperature does not exceed 400° to 450°, the percentage of heat lost through the chimney is very small. It is possible to obtain such results with well-proportioned plants. Where a careful daily record of boiler duty has been maintained for several years with boilers of a *nominal* capacity of 100 horse-power each, and set in accordance with this company's designs, such boilers have shown an evaporation of 12½ pounds of water from and at 212°, per pound of combustible, and an *actual* capacity of 130 horse-power. When running at full capacity such boilers frequently develop 175 horse-power, with an economy of nearly 11 pounds of water evaporated per pound of combustible, for a week's run of daily duty in the mill. The flue temperature observed in such cases ranges from 400° to 500°. Economy and capacity in the generation of steam are not to be found in the most complex systems, but in those which are simple and which are constructed in harmony with the laws of nature.

Inspectors' Report.

DECEMBER, 1894.

During this month our inspectors made 7,914 inspection trips, visited 16,834 boilers, inspected 6,499 both internally and externally, and subjected 772 to hydrostatic pressure. The whole number of defects reported reached 12,409, of which 1,610 were considered dangerous; 79 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	842	44
Cases of incrustation and scale,	2,042	107
Cases of internal grooving,	101	19
Cases of internal corrosion,	669	37
Cases of external corrosion,	789	49
Broken and loose braces and stays,	175	58
Settings defective,	351	30
Furnaces out of shape,	457	19
Fractured plates,	291	83
Burned plates,	238	47
Blistered plates,	222	8
Cases of defective riveting,	1,437	224
Defective heads,	136	12
Serious leakage around tube ends,	2,645	640
Serious leakage at seams,	571	46
Defective water-gauges,	459	71
Defective blow-offs,	178	40
Cases of deficiency of water,	33	12
Safety-valves overloaded,	133	18
Safety-valves defective in construction,	112	20
Pressure-gauges defective,	457	20
Boilers without pressure-gauges,	4	4
Unclassified defects,	67	2
Total,	12,409	1,610

Summary of Inspectors' Reports for the Year 1894.

During the year 1894 our inspectors made 94,982 visits of inspection, examined 191,932 boilers, inspected 79,000 boilers both internally and externally, subjected 7,686 to hydrostatic pressure, and found 595 unsafe for further use. The whole number of defects reported was 135,021, of which 13,753 were considered dangerous. A summary of the work by months is given below, and the usual classification by defects is likewise given:

SUMMARY, BY DEFECTS, FOR THE YEAR 1894.

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	10,446	587
Cases of incrustation and scale,	23,000	923
Cases of internal grooving,	1,277	125
Cases of internal corrosion,	7,679	458
Cases of external corrosion,	9,543	638
Defective braces and stays,	2,128	649

Nature of Defects.	Whole Number.	Dangerous.
Settings defective,	4,289	452
Furnaces out of shape,	5,274	236
Fractured plates,	3,655	692
Burned plates,	3,087	293
Blistered plates,	3,153	175
Defective rivets,	15,828	922
Defective heads,	1,400	222
Leakage around tubes,	22,355	4,221
Leakage at seams,	5,869	412
Water gauges defective,	4,610	760
Blow-outs defective,	2,032	548
Cases of deficiency of water,	239	122
Safety-valves overloaded,	835	267
Safety-valves defective,	1,159	378
Pressure gauges defective,	6,053	438
Boilers without pressure gauges,	200	200
Unclassified defects,	910	35
Total,	135,021	13,753

Summary by Months.

Month.	Visits of inspection.	Number of boilers examined.	No. inspected internally and externally.	No. tested hydro-statically.	No. condemned.	Number of defects found.	Number of dangerous defects found.
January,	9,334	17,973	6,430	525	79	10,615	1,110
February,	7,347	15,515	5,769	456	47	10,273	1,333
March,	7,915	16,700	6,512	527	63	11,324	1,181
April,	7,646	16,003	7,061	642	44	11,355	1,071
May,	8,142	15,966	6,893	735	35	11,613	1,123
June,	7,467	13,931	6,702	706	25	11,308	976
July,	7,698	15,151	8,242	630	61	11,160	1,102
August,	7,325	14,730	6,309	656	31	10,757	1,261
September,	7,824	15,253	6,542	652	31	11,292	1,195
October,	8,509	18,024	6,556	747	47	12,323	910
November,	7,861	15,852	5,485	638	53	10,592	881
December,	7,914	16,834	6,499	772	79	12,409	1,610
Totals,	94,982	191,932	79,000	7,686	595	135,021	13,753

The following short table shows the increase in the work of our inspectors during the past year:

Comparison of Inspectors' Work during the Years 1893 and 1894.

	1893.	1894.
Visits of inspection made,	81,904	94,982
Whole number of boilers inspected,	163,328	191,932
Complete internal inspections,	66.698	79,000
Boilers tested by hydrostatic pressure,	7,861	7,686

	1893.	1894.
Total number of defects discovered, - - -	122,893	135,021
" " of dangerous defects, - - -	12,390	13,753
" " of boilers condemned, - - -	597	595

We append, also, a summary of the work of the inspectors of this company from 1870 to 1894, inclusive. The years 1876 and 1878 are omitted, because the data that we have at hand for those years is not complete. The figures, so far as we have them, indicate that the work during those years was in good accordance with the regular progression observable in other years. Previous to 1875 it was the custom of the company to publish its reports on the first of September, but in that year the custom was changed and the summaries were made out up to January 1st, so as to agree with the calendar year. The figures given opposite 1875, therefore, are for sixteen months, beginning September 1, 1874, and ending December 31, 1875.

SUMMARY OF INSPECTORS' WORK SINCE 1870.

YEAR.	Visits of inspection made.	Whole number of boilers inspected.	Complete internal inspections.	Boilers tested by hydrostatic pressure.	Total number of defects discovered.	Total number of dangerous defects discovered.	Boilers condemned.
1870	5,439	10,569	2,585	882	4,686	485	45
1871	6,826	13,476	3,889	1,484	6,253	954	60
1872	10,447	21,066	6,533	2,102	11,176	2,260	155
1873	12,824	24,998	8,511	2,175	11,998	2,892	178
1874	14,368	29,200	9,451	2,078	14,256	3,486	163
1875	22,612	44,763	14,181	3,149	24,040	6,149	216
1877	......	32,975	11,629	2,367	15,964	3,690	133
1879	17,179	36,169	13,045	2,540	16,238	3,816	246
1880	20,939	41,166	16,010	3,490	21,033	5,444	377
1881	22,412	47,245	17,590	4,286	21,110	5,801	363
1882	25,742	55,679	21,428	4,564	33,690	6,867	478
1883	29,324	60,142	24,403	4,275	40,953	7,472	545
1884	34,048	66,695	24,855	4,180	44,900	7,449	493
1885	37,018	71,334	26,637	4,809	47,230	7,325	449
1886	39,777	77,275	30,868	5,252	71,983	9,960	509
1887	46,761	89,994	36,166	5,741	99,642	11,522	622
1888	51,483	102,314	40,240	6,536	91,567	8,967	426
1889	56,752	110,394	44,563	7,187	105,187	8,420	478
1890	61,750	118,098	49,983	7,207	115,821	9,387	402
1891	71,227	137,741	57,312	7,859	127,609	10,858	526
1892	74,830	148,603	59,883	7,585	120,659	11,705	681
1893	81,904	163,328	66,698	7,861	122,893	12,390	597
1894	94,982	191,932	79,000	7,686	135,021	13,753	595

The following table is also of interest. It shows that our inspectors have made nearly a million visits of inspection, and that they have made over a million and three-quarters of inspections, of which nearly seven hundred thousand were complete internal inspections. Of defects, over a million and a third have been discovered and pointed out to the owners of the boilers; and nearly one hundred and seventy thousand of these defects were, in our opinion, dangerous. Nine thousand boilers have been condemned as unsafe, good and sufficient reasons for the condemnation being given in each case.

Grand Total of the Inspectors' Work Since the Company Began Business, to January 1, 1895.

Visits of inspection made,	891,707
Whole number of boilers inspected,	1,771,992
Complete internal inspections,	687,786
Boilers tested by hydrostatic pressure,	109,881
Total number of defects discovered,	1,341,330
" " of dangerous defects,	168,502
" " of boilers condemned,	9,001

Boiler Explosions.

December, 1894.

(304.)—The boiler in Pinkerton Misenheimer's saw-mill, Cabarrus county, N. C., exploded on December 1st. The engineer, Milas Misenheimer, was scalded so badly that he died shortly afterwards.

(305.)—A small boiler exploded on December 1st, in Louisville, Ky. Otto Shrieck was badly scalded about the face, arms, and breast, and William Kirk, an assistant, was painfully bruised. Both men will recover, but Mr. Shrieck will be permanently disfigured.

(306.)—The boiler of locomotive No. 187, of the Norfolk & Western railroad, exploded on December 3d, at Nolan Station, near Kenova, W. Va. Fireman A. M. French was badly scalded, and one of his legs was broken. It is feared that he cannot recover. Engineer G. W. Croky escaped without serious injury.

(307.)—A boiler exploded on December 3d, in Greene, a village in the north-western part of Coventry, R. I. John A. Brown and Lyman Scott were instantly killed, and John E. Gladding, William Cushman, and Levi Remington were seriously injured. The shell of the boiler was found in a swamp, 250 feet from its original position. The building in which the boiler stood was wrecked. The explosion appears to have been caused by simple over-pressure, as the steam-gauge is said to have indicated 129 pounds a few moments before it occurred. The boiler was built of quarter-inch iron.

(308.)—A boiler exploded at Gray's elevator, Sabina, O., on December 5th. Nobody was hurt. The boiler landed 300 feet from its original site, and in its flight it tore the side out of a box car.

(309.)—The boiler in H. D. Richardson's cotton-gin at Elmo, Texas, exploded on December 5th. Mr. Richardson was injured, but will recover.

(310.) — On December 7th a boiler exploded near Carey, O., injuring Nicholas Goesche so badly that he died a few hours later.

(311.)— A boiler exploded, on December 7th, in Danby, Tompkins county, N. Y. William Bierce and a man named Van Lieu were killed, and Henry Beardsley and Fremont McFall were scalded so badly that they cannot recover.

(312.)— On December 8th a boiler exploded at Highland Village, near Lanesboro, Minn. Anton Simmons and a young man named Ellestad were scalded badly. Edward Overland was struck on the head by a piece of iron, and it is thought that he will die. At last accounts he was still unconscious.

(313.) — Ex-Mayor E. M. Short's steam saw-mill, at Washington, N. C., was wrecked on December 10th, by the explosion of one of a nest of four boilers. The exploded boiler was shattered into a thousand pieces. Mr. Short was killed, and so also were the engineer, two firemen, and a teamster. Two other operatives were injured.

(314.)— A boiler exploded on December 11th, at the Vincennes Novelty Works, Vincennes, Ind. The boiler room and plating room were completely wrecked, and the property loss is probably between $2,000 and $3,000. Harry Lane, a boy who was playing in the neighboring school-yard, was stunned by a brick, and although the extent of his injuries is not known, his physician did not consider them to be necessarily fatal. Charles Hodapp, another boy, was also struck in the head in the same manner, but his injuries were not serious.

(315.)— A boiler exploded at Whalen, Minn., on December 12th, and wrecked a neighboring dwelling-house belonging to Eben Gilles. Six persons were injured, but none of them fatally.

(316.)— One of the boilers in Willy & Co.'s flouring mill, at Appleton, Wis., exploded on December 15th. Engineer John Steinel and a laborer named Joseph Kreuzer were instantly killed. Two other persons were injured, and the property loss was about $12,000. A similar explosion occurred in this same mill on January 13th, 1894. (See THE LOCOMOTIVE for March, 1894, page 36, explosion No. 13.)

(317.)— Four men were injured, on December 16th, by the explosion of a boiler in Bronson township, Ohio.

(318.)— By the explosion of a boiler at Happly Hollow, Schoharie county, N. Y., on December 16th, William Hanson and Harry Tremont were fearfully scalded, and a man named Van Allen was badly injured. All three of the men may die.

(319.)— The boiler of an illicit still exploded in Quebec, Ontario, on December 17th, and nine persons were badly burned. It transpired that the still was owned by a sergeant of the city police!

(320.)— A boiler exploded on December 18th, in Russell Bros.' mill, at West Bay City, Mich., John Calcutt, George Pfund, Albert Heubenbecker, Albert Rahn, and John Braun, were killed, and Charles Doege, Roe Hudson, and Fred Wildanger were injured. Mr. Doege's injuries were quite serious, but he will live. The boiler house, the dry-kiln, and the east end of the factory were wrecked. The property loss is variously estimated at from $5,000 to $12,000.

(321.)— A boiler exploded in Peabody's mill, Paris, Ill., on December 19th. Benjamin Johnson, D. B. Peabody, and Samuel Richmond were seriously injured; Johnson died three days later, and Peabody is not expected to live. Part of the boiler was found 600 feet away. It had passed through a house in its flight, but none of the occupants were injured.

(322.)—A large kitchen boiler exploded in Gallipolis, Ohio, on December 19th. The building was considerably damaged, cooking utensils were thrown in every direction, and a servant in the kitchen was severely scalded.

(323.)—On December 19th a boiler exploded in Highland, near St. Paul, Minn. The boiler was constructed of steel, and the State inspector allowed the owners to carry a pressure of 120 pounds to the square inch. At the time of the explosion the gauge showed 165 pounds. The fusible plug, it was found, had been filled with babbitt metal instead of with tin, as required by law.

(324.)—A boiler exploded on December 21st in Trainor's mill, four miles north of Bellmont, near Mt. Carmel, Ill. George Trainor (a son of the proprietor) was killed instantly. Braden Myrick, the engineer, was bruised and scalded so badly that he died of his injuries within 24 hours. John Trainor, the owner of the mill, was seriously injured, but may recover. Zion Lambert, an employe, was scalded severely but not fatally. The boiler had no steam gauge, and our account says that the "pop-off" was set at 100 pounds, but that it was so defective that the boiler may have been carrying as much as 200 pounds.

(325.)— A saw-mill boiler exploded on December 22d, at Bonayr, Barren county, Ky. Robert Bird and a man named Spann were killed outright, and Claude Deering, Mr. Spann's son, and another man whose name we could not learn, were fatally injured. The mill was almost totally destroyed.

(326.)— A boiler exploded on December 23d in a tile factory at Elgin, Ill. The explosion did considerable damage, but nobody was hurt.

(327.)—On December 25th two boilers exploded in the Chewalla cotton mills, near Eufaula, Ala. One man, who was in the boiler room at the time, was injured quite badly, but he will recover. The mills were considerably damaged.

(328.) — A flue collapsed on December 27th, in a boiler in the basement of the Midland hotel, Kansas City, Mo. John Alba, a fireman, was injured so badly that he died next day, and Engineer Fred C. Patton was injured internally, and is expected to die. Riley Mowen was badly burned, but it is believed that he will recover. Fireman Henry Gable was also slightly injured. The damage to the hotel was small.

(329.)—A small boiler exploded in Springfield, Mass., on December 28th. Crayton Billings, the fireman, received painful injuries, and a young Italian boy was slightly hurt. At last accounts, Mr. Billings was on the road to recovery.

(330.)— A boiler exploded in Carter's mill, near Hinton, W. Va., on December 29th, killing George T. Hall instantly, and seriously injuring Edward Carter and several others. Six years ago a boiler exploded in the same mill, killing five men and injuring eight.

(331.)—A kitchen boiler exploded on December 30th, in the residence of Mr. W. J. Barnes of Tuscaloosa, Ala. The kitchen range was completely demolished, and furniture was blown through the ceiling of the room. Mr. Barnes was struck by a fragment of iron and painfully injured.

The Locomotive.

HARTFORD, FEBRUARY 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

IN these *fin de siècle* days we look to the theater to give us faithful representations of saw-mills in action, of mountain torrents, of earthquakes, of volcanic eruptions, and of whatever other startling thing the fertile imagination of the manager can conjure up and the stage carpenter can construct. We confess, however, that we had not looked for a genuine boiler explosion; and yet, behold! it has come to pass. An advertisement in an esteemed contemporary notifies us that this very thing is given "in the new Uncle Hiram" (whatever that may be), six evenings in the week, with Saturday matinées; and the further advice is given, "Don't fail to see it at the Opera House."

A BOILER in England burst recently, and, at the inquest held upon it, a person testified that he had examined the boiler all over — or at least where he could get at the parts without trouble — and found it safe. He had never examined a boiler before, but he thought he was quite capable of it, and presumed the whole boiler was safe because he did not see any defects in a cursory inspection; his opinion was that "black heat" caused the explosion. It only remains to add that this gentleman was ordered to pay $50 towards the cost of the inquest, not, possibly, because of his "black heat" opinion, but to teach others to be more careful in future. — *The Engineer* (New York).

Fast Living.

The most remarkable instance of rapid growth is said to be recorded by the French Academy in 1729. It was a boy of six years of age, 5 feet 6 inches in height. At the age of five his voice changed, at six his beard had grown, and he appeared a man of thirty. He possessed great physical strength, and could easily lift to his shoulders and carry bags of grain weighing two hundred pounds. His decline was as rapid as his growth. At eight his hair and beard were gray; at ten he tottered in his walk, his teeth fell out, and his hands became palsied; at twelve he died with every outward sign of extreme old age. — *Times and Register.*

[This reminds us strongly of the precocious baby whose brief but eventful biography is given in Mr. W. S. Gilbert's *Bab Ballads.* After giving numerous illustrations (with both pen and pencil) of the extraordinary sophistication of this infant, Mr. Gilbert tells us that

"He died, an enfeebled old dotard, at five."

— ED.]

The Importance of Ductility in Boiler Plates.

The evidence given at the inquest on the fatal explosion which occurred on Dec. 17th, at the Henry Rifled Barrel and Small Arms Factory, Hoxton, [Eng.,] and by which two men were killed and half a dozen seriously injured, shows once more the importance of steam-users insisting upon the employment of nothing but the very best material in the construction of steam boilers.

It is not sufficient for boiler plates that they are capable of standing a considerable tensile stress. Measured by this standard alone, steel and iron may appear to be fairly satisfactory, and yet as boiler materials they may be utterly worthless. What is of far more importance than tenacity is, that the material shall be *ductile* — that is to say, capable of being drawn out before breaking. In virtue of this property the structure is capable of adjusting itself to the various stresses that are imposed on the material during the process of construction, as well as those arising from unequal expansion and contraction when the boiler is set to work. How serious and complex the nature of these stresses is, only engineers who have made a special study of the working of steam boilers adequately realize. The boiler in the explosion under notice was of the externally fired type, a class which . . . is specially liable to stresses from the action of the fire, and therefore one in which the employment of a good ductile material is the more necessary.

In the absence of the detailed report of the Board of Trade, which will, however, be issued in due course, we cannot state precisely the cause of the disaster. It would appear most probable, however, that it arose from a rip at one of the longitudinal seams. But of one thing there is no doubt, and that is that the wretched character of the material of which the boiler was made contributed largely to the result. In the course of the inquest, evidence was given which clearly proved this point. Test strips of the plates, which were of iron, gave a tenacity of 21.97 tons pulled in the direction of the grain, and 18.89 tons pulled across the grain. As a tensile strength this may seem fairly good, and it is only when we turn to the percentage of elongation that we clearly realize the wretched character of the stuff. This on a length of 10 in. was only 4 per cent. and 1.9 per cent. respectively. The two samples named were taken from plates exposed to the action of the fire. These results were fully confirmed by two other specimens cut from a plate away from the fire, which gave a strength of 19 tons per square inch, and 17 tons per square inch with the grain and across the grain respectively, the corresponding elongations being 3.7 per cent. and 1.4 per cent. in a length of 10 inches. How miserably deficient the material was in the all-important property, *ductility*, will be realized when it is stated that similar test pieces of good iron boiler plates would give an elongation of something like 7 to 10 per cent., while mild steel would afford an elongation of upwards of 25 per cent. The material was what is technically known as "best" iron. As a matter of fact, it was about the worst quality that could possibly be used, and utterly unfit for boilers. With such brittle plates and punched holes, it is easy to understand that the use of a drift, which would be almost inevitable (since some of the rivets were not fair in the holes), would go a long way towards establishing cracks in the first instance, and that it would only be a question of time for such incipient flaws to develop into open rupture.

We have stated that the quality of the plates was that known as "best" iron. The use of this phrase by makers of iron plates is very misleading to steam-users who have no technical knowledge, and, therefore, it may not be out of place if we explain that the qualities of iron plates are roughly designated in the trade [in England] as "best,"

"best best," and "treble best." Thus the brand designated as "best," is in reality the worst that can be employed, and its use in boiler construction should, in our opinion, be made criminal.

At the inquest the usual verdict of "accidental death" was returned, the jury stating that they agreed with the engineer of the London County Council, who gave evidence, and stated that in his opinion the explosion was due to the brittleness of the material, coupled with bad riveting and the unequal strain induced by external firing, adding that the disaster was not the result of any special act or circumstance.

When a boiler explosion is clearly proved to be due to bad workmanship and worse material, it cannot, in our opinion, be regarded as accidental. Surely someone is, or ought to be, responsible for the material and workmanship employed in the construction of a steam boiler. Happily, the matter will not be allowed to rest where it is; the Board of Trade will, no doubt, make an inquiry in due course, and the question of responsibility for the defects that have been proved to exist, will probably be brought home in a highly unpleasant manner to the parties concerned.— *Practical Engineer* (Eng.).

Thick Fires.

It is the prevailing opinion with some that it is necessary when a boiler is worked to a high rate of capacity to maintain correspondingly heavy fires. It is argued that thin fires are well enough for slow rates of combustion, but as the call for steam increases it must be met by an increased thickness in the bed of coal on the grate. Where heavy fires are carried it is a common thing for the fireman to shovel in all the coal that he can conveniently supply, going so far as to almost fill the opening at the fire door, leaving little if any room for a future supply until that already in has been pushed back to make room for more. The ordinary fireman is apt to favor this method, for the reason that he can introduce large quantities at a firing, and afterwards he is not obliged to give the fires much attention for perhaps an hour's time, when he will again fill the furnace full in the same manner as before. This method of firing with most of the high-class bituminous coals in use in the Eastern States requires from time to time the use of the slice bar for breaking up the bed of coal. It has always seemed to the writer that whatever necessity there may be according to the popular idea for carrying heavy fires, in the matter of the amount of labor involved it is in reality more laborious for the fireman than it would be if the fires are kept comparatively thin and small quantities of coal supplied at each firing. As an explanation, however, of the favor which this method receives, it is probable that the class of labor which is generally employed considers the muscular effort required much less of a task than the more frequent and careful attention which is needed when the fires are kept at medium thickness.

As regards a comparison between thick and thin fires, the fact is that more capacity can be obtained from a boiler when a fire of medium thickness is carried and proper attention is given to its condition than can be realized by any system of management when the fires are exceedingly heavy, and advocates of thick fires, who take the ground that they are a necessity when boilers are forced, are entirely mistaken. As to the economy of the two, some persons maintain that heavy fires give the most economical results, but this is questionable. Valuable information on the subject has recently been brought out by the results of two evaporative tests, which we give below. They were made on a 72-inch return tubular boiler having 1,000 3½-inch return tubes, 17 feet in length. The heating surface amounted to 1,642 square feet, and the grate surface to 36 square feet, the ratio of the two being 45.6 to 1. On the thick fire test the depth of the coal on the grate varied from 8 to 20 inches, being heaviest at the rear end and lightest at the front end. On the thin fire test the depth was maintained uniformly at about 6 inches. The fuel was New River semi-bituminous coal. The difference in the results as appears from the figures is an increased evaporation due to thin fires amounting to 15.6 per cent.

	Condition as to thickness of fires.	Thick fires.	Thin fires.
1.	Average boiler pressure, pounds,	131.6	130.4
2.	Average temperature feed water, degrees,	39.6	43.5
3.	Average temperature flue gases, degrees,	484	487
4.	Average draught suction, inches,	0.17	0.18
5.	Per cent. moisture steam, per cent.,	0.25	......
6.	Coal per hour per square foot grate, pounds,	13.72	12
7.	Per cent. ashes, clinkers, per cent.,	5.1	5.7
8.	Horse power developed on basis 30 pounds from 100° and at 70 lbs., horse power,	140.3	144.4
9.	Water evaporation per pound coal, pounds,	8.517	9.457
10.	Equivalent evaporation, per pound of combustible from and at 212 degrees, pounds,	10.985	12.234

— *Scientific American.*

Molecules.

For the past 2,000 or 3,000 years, philosophers have taken special delight in theorizing about the nature of matter. Their theories, until recently, were not based upon a study of nature, but were evolved from their inner consciousnesses, and were the products of meditation rather than of experiment. Some of the views of these early philosophers have turned out to be surprisingly near the truth, while others are absolutely absurd and ridiculous. Nowadays the physicist pursues a very different method. He studied the properties of matter as they are manifested in his laboratory and elsewhere, and strives to discover the simplest constitution of matter that would suffice to explain these properties. He always checks himself carefully by the facts, and his theories are accepted or rejected according as they agree with these facts or disagree with them. They are also judged according to their intrinsic reasonableness. It is easy enough, comparatively, to find out whether a theory agrees with the facts or not, but it is not so easy to say that is reasonable or unreasonable; for this will depend to a large extent upon the state of knowledge at the time and upon the year of grace in which the theory is propounded. It is a notorious fact that things that are absurd to one generation are often mere commonplaces to the next one.

The sound and healthy growth of our knowledge of the constitution of matter can fairly be said to have begun with the present century. In 1805 Dalton, a celebrated English chemist, called attention to the fact that when substances combine with one another they do so in certain definite proportions; and he felt that the easiest way to explain this was to assume that all bodies consist of small particles, which come together in pairs, or in threes, or fours, when these bodies combine. This would explain the law of definite proportions, a law which is difficult to account for by any other hypothesis. There are many other reasons for believing that matter is not homogeneous, as it often appears to be to our senses, among which may be mentioned the dispersion of light by a prism. It is difficult to understand why a light of one color should be refracted either more or less than one of another color, unless we suppose that the transparent substance composing the prism really has a grained structure, and that the distance between its particles is comparable with the wave-length of the light. The high vacuum tubes constructed by Mr. Crookes afford a most convincing proof of the molecular constitution of gases, but we cannot dwell upon them, interesting as they are, in the present article.

All bodies may be classified in general as solids, liquids, and gases. This classification is by no means perfect, because there are many substances, such as tar and certain kinds of wax, which are brittle, and are apparently solids, but which nevertheless will flow like a liquid *if we give them time enough*. According to the present views of physicists, solid bodies are believed to consist of molecules that are relatively fixed, so far as their positions are concerned. They may be vibrating, or rotating, or oscillating to and fro, but they never depart very far from their average positions unless constrained to do so by the application to the body of some external force. In liquids, as well as in solids, the molecules are believed to be very close together, and well within the range of their mutual powers of attraction. They are not believed to be fixed, however, but are thought to weave their way in and out among one another perpetually, so that in the course of time any given molecule may pass throughout the entire mass of liquid in which it occurs. Gases are believed to differ from liquids in having their molecules further apart, so that the effects of intermolecular attraction are barely perceptible. The molecules of gases are also believed to be traveling with speeds greatly in excess of those which occur in solids and liquids.

It has been found easier to investigate the properties of gases than those of solids and liquids, on account of the simplicity of the physical laws to which they are subject; and hence the molecular theory of gases has been developed much more than the corresponding theory of other bodies. Many of the results that mathematicians have obtained by studying the inter-action of flying molecules are extremely interesting, but we can touch only upon one or two of the most rudimentary of them. It has been shown that the "absolute temperature" of a gas is proportional to the square of the average speed of its molecules. As the molecules strike against the walls of the vessel containing them, they act like so many rubber bullets fired out of a gun, and as they are extremely numerous they produce the effect which we call "gaseous pressure." When a liquid is allowed to evaporate, the action is believed to be something like this: The molecules within the liquid are attracted equally in all directions, but those which are at the surface are attracted only downward. Now if a molecule, in the course of its wanderings, comes to the surface of the liquid, it will continue its upward motion for a certain distance, and may even pass away from the liquid altogether. As soon as it has left the liquid, however, the attraction which the liquid exerts upon it is wholly *downward*; and if the escaped molecule is moving slowly, it may not be able to rise very far before the pull of the liquid stops it and makes it fall back again. On the other hand, if it is moving with considerable speed it will be merely slowed down a little, but will continue in its upward course with reduced velocity, and after it has risen to a height of one five-thousandth of an inch, or so, it will no longer feel the attraction of the liquid, but will have become a permanent addition to the vapor above. This explains why liquids do not fly into vapor instantly. It also explains why evaporation *cools* the liquid; for it is only the swiftest molecules that escape, and hence the tendency is to continually reduce the average speed of those that are left. If the liquid is enclosed in an air-tight vessel the evaporation will not go on indefinitely, but a state of equilibrium will be attained when the vapor over the liquid acquires a certain density; because, although molecules continue to escape from the liquid as before, yet as the density of the vapor increases a larger and larger number of molecules will happen to fall back into the liquid again, and get entangled within it — the apparent equilibrium being attained when the number of molecules that leave the liquid in a given time is precisely equal to the number of those that chance to plunge back into it out of the vapor.

The pressure that the gas exerts against the vessel containing it being due to the molecular bombardment of the walls, it is an easy matter to calculate the speed that the molecules must have in order to give the observed pressure. It is found, for example, that molecules of air under ordinary conditions of temperature and pressure have an average velocity of about 2,000 feet per second. The speed is even higher in hydrogen gas, whose molecules travel, on an average, more than a mile in one second. Of course there must be frequent collisions between the flying molecules of gases; and it has been shown that the average distance that a molecule of the air travels between two successive collisions with its neighbors, is about three one-millionths of an inch. It is easy from these data to show that the number of collisions experienced by a molecule of air in one second is about five thousand millions.

When we come to consider the sizes of molecules, and the absolute number of them in a given volume of gas, we find that molecular science is not yet able to give us a very precise answer. Many methods for finding the sizes of molecules have been proposed, but a general discussion of them would be out of place in this article. One of the simplest of them is known as the "method by camphor movements." If camphor scrapings be dropped upon an absolutely clean water surface, they will at once exhibit surprisingly vigorous movements. This experiment is easily performed, but the most absolute cleanliness is essential to its success. The least trace of oily matter on the water will stop the movements entirely. We need not enter upon the explanation of the astonishing behavior of the camphor particles, further than to say that it is a "surface phenomenon" entirely, and that the molecules of water below the surface have nothing to do with it. As soon as the water is covered by an oil film, however thin, the movements cease, as we have said. By using a large tank of water, and allowing a very small but known quantity of oil to spread over it, it has been found that the camphor particles are brought to rest by a film of oil about .00000006 of an inch thick. We do not know that this film of oil is precisely one molecule thick, but we *do* know that its thickness cannot be *less* than that. Other methods, entirely different in principle and based upon experiments of very different kinds, give substantially the same results; and hence we conclude that the figure just given is of about the right order of magnitude for the diameters of molecules. By compressing gases strongly, so that they begin to deviate from Boyle's law, it is possible to show what proportion of the volume of the gas is actually filled by molecules, and what proportion of it is empty space. In hydrogen gas, for example, we find that only about $\frac{1}{8000}$th of its volume, under ordinary conditions, really consists of matter — the rest of it being empty. Knowing in this way the total volume of the molecules, and having found by other methods the diameter of a single molecule, we can find how many molecules there are in a cubic inch of the gas. Thus it is found that in all gases, at atmospheric pressure and at the freezing point, there are about 100,000,000,000,000,000,000 molecules in each cubic inch.

Such numbers as this, obtained from a study of things that surround us on all sides, put to shame the boasted big numbers of astronomy. It is impossible to conceive them, and an illustration will perhaps serve to make their significance a little easier to grasp. If the molecules contained in a cubic inch of hydrogen were placed in contact in a straight line, they would reach 32,000,000 miles, or about one-third of the way from the earth to the sun. (This seems like an impossibility, but it can be easily shown to be true.) To gain a further idea of the number of molecules in a cubic inch of gas, it may be said that if these molecules were spread out on a plane so that the average distance from one molecule to its neighbor was the same as the average distance between the centers of the letters on this page, the sheet thus formed would wrap around the entire earth, and cover it completely.

Incorporated 1866.

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HARTFORD, CONN.

Charter Perpetual.

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The Locomotive.

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NEW SERIES — VOL. XVI. HARTFORD, CONN., MARCH, 1895. No. 3.

On Boilers with Single Fire Sheets.

Some few years ago it was quite common to build boiler shells with short courses of plates, the rings, in many cases, being not more than three feet long. The reason for this mode of construction was that it was very difficult at that time for the rolling mills to turn out larger plates that were both uniformly good in quality and cheap enough to compete in the market with the smaller ones. With the gradual improvement of methods of manufacture, and the introduction of larger and better machinery in the plate mills, the various objections to large plates lost their cogency, and at the present day boilers with three courses (or four courses, at the most,) are almost univer-

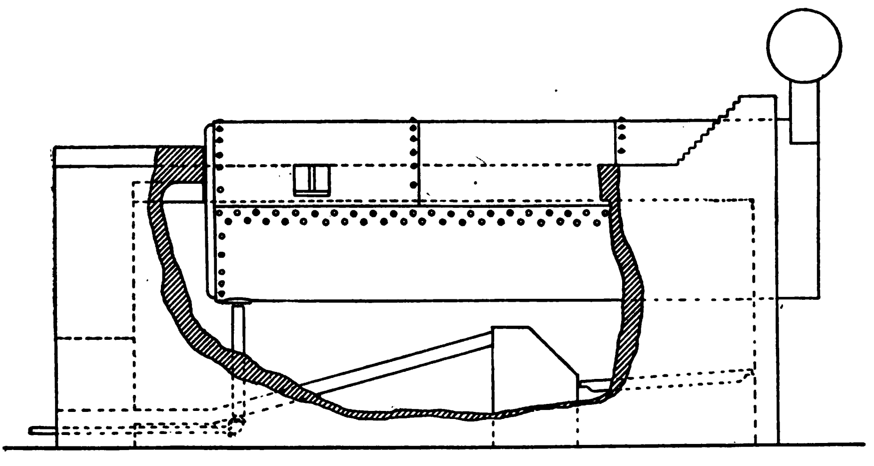

FIG. 1.— ELEVATION OF A SINGLE-SHEET BOILER.

sal. The effort to make larger and larger plates has by no means ceased, and to-day we find many large boilers constructed as shown in Figs. 1 and 2, the lower half of the shell being composed of a single sheet of unusual size, while the upper half is composed of three courses of smaller plates, as before.

The single fire-sheet is used with the idea that much is gained by keeping the girth-joints up out of the fire, and undoubtedly the construction in question is good, so far as this one point goes. We have no desire to condemn these big, single-sheet boilers — in fact, we have repeatedly accepted them for insurance, and shall probably continue to accept them so long as they are otherwise well-designed and well-made — but we wish to explain why we are not as enthusiastically in favor of them as their advocates have expected us to be.

In the first place, we hold that since the longitudinal joints are always subject to greater strain than the girth-joints, it is much more important to protect the former from the fire than the latter. If the reader will carefully observe Figs. 1 and 2, he will readily understand the point we wish to make. Putting aside all question of the greater liability to defects that the big single sheets may have, the fact remains that these sheets, *when used on large boilers*, are not wide enough to allow the builder to carry the longitudinal joints above the fire line. These joints are located below the lugs or brackets that support the boiler, and are, therefore, subject to the unobstructed and intense heat of the furnace; so that, although the new construction does away with *girth* joints in the furnace, and in this respect is an improvement, as we have already admitted, yet it involves the grave defect of exposing the *longitudinal* joints to the fire. We have long maintained that boilers should be so constructed that all longitudinal joints will be well above the fire-line, and covered in by the brick-work. Figs. 3 and 4 illustrate the construction that we have recommended for this purpose. There are three rings of plates, as will be seen, and the longitudinal joints are well protected.

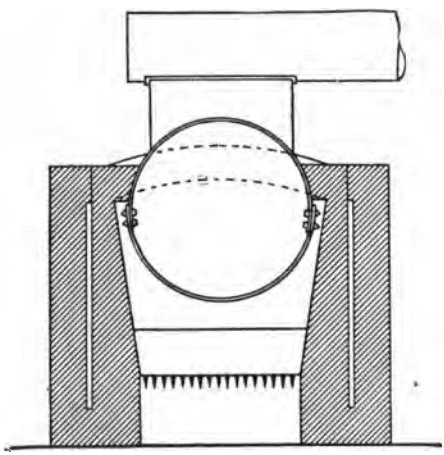

FIG. 2.—SINGLE-SHEET BOILER.

The single bottom plate has been used for some years in the construction of boilers of comparatively *small diameter*, to be used at ordinary pressures; but in these cases the plate has been wide enough to carry the longitudinal joints above the fire-line—a point of difference well worth serious consideration. It does not follow, from the admitted excellence of these earlier and smaller boilers, that the same principle of construction is advisable for the large, high-pressure boilers that our modern compound, triple, and quadruple-expansion engines require.

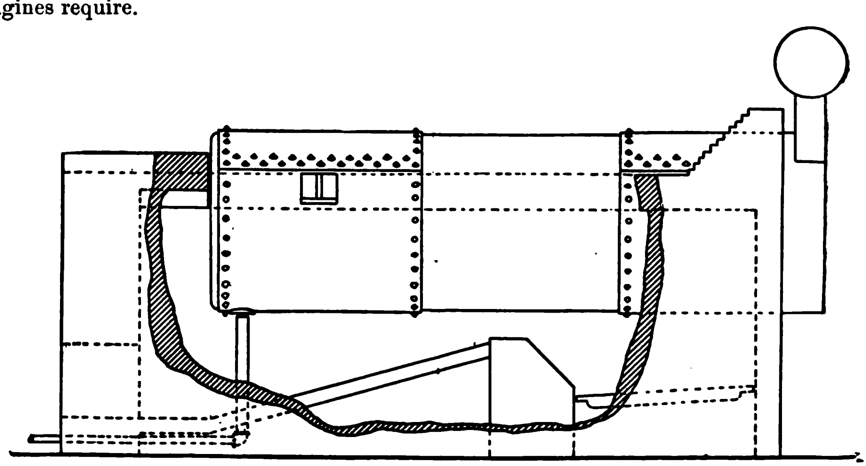

FIG. 3.—ELEVATION OF A THREE-RING BOILER.

Another point to which the attention of boiler-makers and steam-users is earnestly called is the fact that in the new construction the longitudinal joint extends without a break from one end of the boiler to the other. The principle of "breaking joints" is observed in carpentry, masonry, bridge-building, and other constructive arts: we do not see why it is not also applicable to boiler making.

We wish to move with the times in the matter of boiler construction, and we have no desire to "be the last by whom the old is laid aside"; but at the same time we feel that there are two sides to the single-sheet question, and which of them is right can only be finally settled by experience. If it be urged that the new design works well in practice, we can only reply that such a conclusion is hardly yet warranted by the data at hand. We must wait until many more such boilers are built, and until they have been fully tested under actual running conditions, before any final and trustworthy conclusion can be reached. We may say, however, that we have known of trouble from the single sheet already. Fig. 5, for example, represents a boiler of this kind that recently exploded in an electric light plant, with disastrous results. This boiler was 66 inches in diameter and 16 feet long, with 54 four-inch tubes. It was made of steel, $\frac{3}{8}$ of an inch thick, and the longitudinal joints were double riveted. As will be seen from the cuts, there were three courses on the top, and a single sheet on the bottom. The lines of fracture are indicated in the cut, and there was every indication, both from the final disposition of the fragments of the boiler and from a study of the reduction in area along the torn edges of the plates, that the initial rupture was at the point indicated by the arrow. There was also good reason for believing that the explosion was primarily due to the single-sheet construction, and the consequent exposure of the longitudinal joint to the fire. Two persons were killed by this explosion, and three seriously injured, and the property loss was estimated at $50,000.

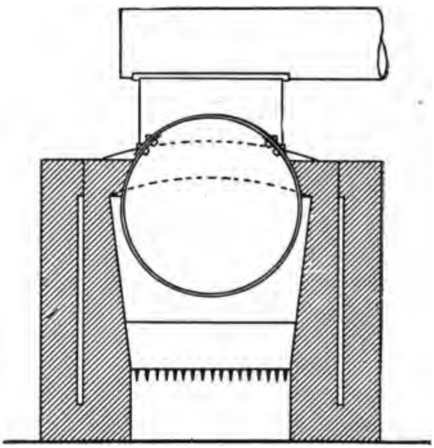

FIG. 4.—THREE-RING BOILER.

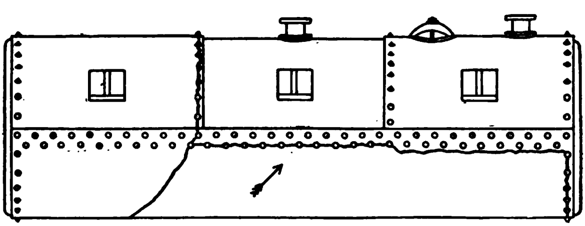

FIG. 5.—SHOWING LINES OF FRACTURE IN A SINGLE-SHEET BOILER.

Inspectors' Report.

MARCH, 1895.

During this month our inspectors made 8,308 inspection trips, visited 17,504 boilers, inspected 4,355 both internally and externally, and subjected 539 to hydrostatic pressure. The whole number of defects reported reached 10,726, of which 990 were considered dangerous; 37 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	815	52
Cases of incrustation and scale,	1,753	73
Cases of internal grooving,	85	5
Cases of internal corrosion,	576	32
Cases of external corrosion,	712	45
Broken and loose braces and stays,	224	104
Settings defective,	315	24
Furnaces out of shape,	383	16
Fractured plates,	381	47
Burned plates,	212	28
Blistered plates,	231	8
Cases of defective riveting,	1,482	57
Defective heads,	106	16
Serious leakage around tube ends,	1,833	227
Serious leakage at seams,	418	38
Defective water-gauges,	394	85
Defective blow-offs,	147	42
Cases of deficiency of water,	18	11
Safety-valves overloaded,	82	26
Safety-valves defective in construction,	80	27
Pressure-gauges defective,	391	23
Boilers without pressure-gauges,	3	3
Unclassified defects,	85	1
Total,	10,726	990

Boiler Explosions.

JANUARY, 1895.

(1.)—On January 1st a boiler exploded in Salzenstein Bros.' rendering works, near East Peoria, Ill. Superintendent Jackson James was blown 150 feet and instantly killed, and the works themselves were almost totally wrecked.

(2.)—A small boiler belonging to William Kirkwood, at Pinoak, near Oil City, Pa., exploded on January 3d. The boiler-house was wrecked, but Kirkwood, who was the only one about the place at the time, escaped without injury.

(3.)—By the explosion of a boiler in Metz, Mo., on January 4th, C. B. Wilson and W. W. Smith were fatally injured. Mr. Wilson was scalded and bruised about the head, and Mr. Smith had an arm and a leg broken, and was scalded severely and injured internally. P. C. Smith and E. Gillespie were also scalded and bruised about the head and shoulders.

(4.) — A boiler exploded on January 4th at Rosston, ten miles east of Lebanon, Ind. No one was in the building at the time, but five men who were in the yard had narrow escapes from death. The mill was completely wrecked, one side of it being blown bodily out and carried a distance of 200 feet.

(5.) — On January 4th a boiler exploded in the Fordville Coal Company's shaft-house at Ford, Iowa. The boiler was thrown about 200 yards, and all the framework and elevators caught fire and were destroyed. Engineer Solomon Bailey was injured, but not fatally. About fifty men were thrown out of employment, and the loss is estimated at from $4,000 to $5,000.

(6.) — A japanning boiler in the factory of Conchares, Schreiber & Co., at Dubuque, Iowa, exploded on January 7th, causing a fire which damaged property to the extent of about $5,000. Foreman William Dougherty was killed.

(7.) — A boiler exploded in Tench's mill, near Hilda, in Sussex Co., Va., on January 8th. Nobody was injured, and the property loss was not great.

(8.) — A boiler exploded at the works of the Joplin Gas Company, at Joplin, Mo., on January 9th. The power-house was wrecked and the buildings took fire, but the flames were controlled after a desperate fight. The explosion blew the engineer through a window, but it does not appear that he was hurt.

(9.) — A boiler exploded at Convent, La., on January 9th. Joseph Adams had both legs broken.

(10.) — A boiler exploded on January 11th in the electric light plant at Highland Park, near Waukegan, Ill. Nobody was hurt.

(11.) — On January 12th a water-back exploded in the residence of Mr. J. M. Neal of Davenport, Iowa. The entire front of the range was blown off, but fortunately there was no one in the kitchen at the time.

(12.) — Two boilers exploded on January 16th in the thirty-inch mill of the Carnegie steel works at Homestead, Pa. John Greka was firing one of the boilers and Harry Brenneman was standing near him. Both men were hurled across the room, and Brenneman was instantly killed by the concussion. Greka bore few marks of injury, but the shock that he had sustained was so severe that he died shortly afterwards. John Baraak, who was some distance from the exploding boilers, was dashed against a beam, and although it is believed that his skull was fractured, some hope is felt that he may recover. William Banks, who was passing through the boiler-room at the time, received a severe shock and was badly scalded. The property loss is estimated at from $8,000 to $10,000.

(13.) — A small boiler exploded on January 17th near Portland, Ore. The boiler-house was blown to kindling wood, but the engineer, who had just stepped outside, escaped with a black eye. The greater part of the boiler was blown to a distance of 500 feet, striking a derrick in its flight, cutting the boom (a timber sixteen inches in diameter) squarely off, and carrying the butt a distance of 150 feet. There was plenty of water in the boiler, and the safety-valve was in good order.

(14.) — On January 17th a boiler exploded in a cotton gin at Grifton, near Greenville, N. C. Theodore Bland (the proprietor) and John Smith were instantly killed, and another man was painfully but not dangerously injured.

(15.) — A boiler exploded on January 17th in the plow-handle factory at Lebanon, Ind. The entire plant was wrecked. The engineer had noticed something wrong about the boiler, and had just left the boiler-room to inform the foreman. To this circumstance he owes his life.

(16.) — A terrible boiler explosion occurred at the Van Buren saw-mill, eighteen miles southwest of Rusk, Cherokee county, Texas, on January 17th. William Lewis, Alexander Lewis, Tobias Richardson, Alexander Hamilton, and Abner Lee were instantly killed. Emanuel Hamilton and Ashton Miller were injured so badly that they cannot recover, and Nicholas White, Peter Van Buren, Andrew Ross, and Richard Loftin received injuries from which they may recover. Everybody about the mill was killed or wounded, except two boys, who escaped unharmed, although they were standing within a few feet of the boiler.

(17.) — A boiler in Shallmar's mill, near Rison, Ark., exploded on January 19th. J. T. Sumerow was instantly killed, and Charles Valentine, the engineer, died two days later. The engineer's son, Edward Valentine, was so badly scalded that he cannot possibly live, and James McCullough and William Gray were scalded and bruised so that their recovery is doubtful. The property loss is estimated at $30,000.

(18.) — A boiler exploded on January 21st at Indian Camp, fifteen miles northeast of New Concord, Ohio. W. M. Dickson was instantly killed, and Albert Morrow was fatally injured. Elmer McCullough and Oma Evilseizer were also injured, but it is believed that they will recover.

(19.) — One of the boilers in Brownlee & Co.'s saw-mill on the River Rouge, near Detroit, Mich., exploded on January 21st. Frank Collian, the engineer, was instantly killed, and Henry Setske had one arm and one leg torn off, and may die. The property loss was probably about $3,000. Mr. John N. Brownlee, president of the company, said: "I am wholly at a loss to find a cause for the accident. The boiler that exploded was seven years old and was one of a battery of four. The boiler-room had every known appliance for safety. Each boiler was provided with a separate locomotive pop safety-valve and a steam gauge. The boiler that exploded was thoroughly overhauled less than a year ago, and was believed to be in perfect condition. The fireman states that there were three gauges of water in the boiler less than half a minute before the explosion occurred."

(20.) — A boiler exploded on January 23d in Parson Bros.' saw-mill on Sugar creek, six miles southwest of Springfield, Ill. John C. Parsons was killed and the mill was destroyed. The property loss is estimated at $8,000.

(21.) — On January 24th a boiler exploded in the Johnson-Brinkman grain elevator at Rosedale, near Kansas City, Mo. Pieces of boiler-iron were scattered about the neighborhood for blocks. The walls of the engine-room were razed to their foundations and not a brick was left in its original position. Dèbris of all kinds was thrown high into the air, falling in a shower upon the surrounding roofs. The property loss was about $5,000. There was nobody in the building at the time of the explosion.

(22.) — The main building of C. Henning & Son's brewery, Mendota, Ill., was destroyed on January 25th by a fearful boiler explosion. Adam Biersheid, Samuel Deshazo, David Gheer, John Kennedy, Henry Pearl, Christopher Seifert, David Wells, and William Long were killed, and James Love, H. Freeman, A. McLeod, George Parker, Charles Reed, Frank Henning, and Henry Varmore were more or less seriously injured. The property loss was estimated at $100,000.

(23.) — The large boiler of the extensive green-houses owned by Mr. Augustus Doll of East York, Pa., exploded on January 26th. A considerable amount of damage resulted.

(24.) — A boiler exploded on January 27th at the Enz brewery, Allegheny, Pa. The boiler was torn into a dozen pieces, and nothing was left of the boiler-house but the foundations. A large hole was made in the side of Mr. Enz's house, which adjoins the brewery, and Mrs. Enz and her youngest child were painfully injured. The boiler was new and was tested hydrostatically a short time before.

(25.) — A steam boiler used in the government distillery of Mr. T. G. McCowan, Culloden, Ga., exploded on January 28th, scalding Mr. Derwood Sanders so badly that he died later in the day. George McCowan was also fearfully injured, and one of the accounts we have received says that he was killed. Henry Shellworth had both hands blown off and Thomas M. McCowan was badly scalded.

(26.) — A boiler explosion, followed by a panic, took place in the Exchange building at the stock-yards in Chicago, Ill., on January 28th. The exploded boiler formed part of the heating apparatus in the sub-basement. Considerable damage was done in the sub-basement and on the floor immediately above. About twenty-five persons were in the restaurant at the time. They were badly frightened by the shock and the noise, and fled precipitately for the street, overturning tables, chairs, and other furniture, and all joining in a general chorus of howls and screams. They were much more scared than hurt.

(27.) — On January 30th a boiler exploded in the electric power house at Denver, Col. Conrad Bitzer and Frank Walrod were killed, and Edward Stanley, Hugh Ellis, and John Brown were painfully injured. The boiler-house was completely wrecked, and the property loss is estimated at $50,000.

(28.) — John Reedy, a fifteen-year-old boy living in Etna, near Pittsburgh, Pa., was quite seriously injured, on January 30th, by the explosion of a copper boiler connected with a small steam engine of his own make. The boy's head and face were badly scalded, and his eyes were nearly destroyed.

(29.)—A boiler exploded on January 30th, in the windmill factory at Columbus, Neb., tearing out the north wall of the engine room, blowing off the roof, demolishing two walls, and wrecking the machinery. The steam gauge registered ten pounds at the time of the accident. The engineer had left the room about two minutes before the explosion, and nobody was injured.

Poets and philosophers are fond of marveling at the wonders of the human heart, but they usually confine themselves to homilies on its ceaseless activity, and some of the things that are most wonderful of all escape their attention entirely. One of the most remarkable things about the heart is the *amount* of the work it does. Considering the organ as a pump, whose task it is to deliver a known quantity of blood, against a known "head," it is easy to show that in 24 hours a man's heart does about 124 foot-tons of work. "In other words," says a contemporary, "if the whole force expended by the heart in 24 hours were gathered into one huge stroke, such a power would lift 124 tons one foot from the ground. A similar calculation has been made respecting the amount of work expended by the muscles involved in breathing. In 24 hours these muscles do about 21 foot-tons of work."

Finding Squeaks and Knocks in Machinery.

JOHN H. COOPER.

I once sent a boy to find a squeak in a lathe counter-shaft; he returned to me, saying he could not find it. I asked him whether he used his eyes or his ears to hear with. Not understanding me exactly, I then said to him: "Let us go and see if we can find a pulley that makes the same number of turns per minute as the squeaks we hear." We soon found one. "Do you see that?" pointing to the desired pulley. "Yes, sir," he replied. "Now step up to it and oil its shaft." He did so, and silenced the squeak. "Let me now impress this upon your mind so that you will remember it as a lesson well learned," I said; "in future, when you are sent to find a machine-shop squeak, be sure to use your *eyes* as your *ears*." This little incident, which happened forty years ago, I have turned to good account many times since.

Knocks in engines can be found very easily in the same way, by synchronizing the sight and sound of them. Every one knows that the sounds of working machinery are carried to almost every fixed and working part of the same, and unless there are some means known of locating them by coincidence of motion their discovery is very difficult. The fact is generally observed that sounds are loudest where they are made, but we cannot always say, in truth, that sounds gradually decrease in loudness as we withdraw from the sounding body; surrounding objects may have the effect of dispersing or concentrating the waves of air, which carry sounds, so to speak. A concave body will collect the promiscuous sound waves about us, rendering them audible, which, without some special device, would pass by us unheard. So children say: "Put a sea-shell to your ear and hear the ocean roar." In the philosophy of echoes the existence of surfaces which collect and return to us the expanding sound waves are included, but we are at or near the focus of these rays in order to get the benefit of the many vibrations, which, without concentration, would be lost to us. The increase of sound in one locality and its decrease in another diverts the attention, confuses the ear, and makes the locating of its origin difficult in the engine room; therefore it is necessary for the ear to have the aid of the unerring eye to fix the exact place of it and find the cause.

I have often proved the necessity of *seeing* as a strong aid to *hearing*, by pacing back and forth many times the full length of the engine, as a method of locating a "thump," often finding little or no difference in the loudness of the sound, wherever I might be; but as soon as I discovered a concordance of sound and motion, then at once the solution came — there was no uncertainty afterwards. So Schelling says: "In order to see aright one must know to look." The study of acoustics and its illusions is deeply interesting by the peculiar phenomena presented and the startling disclosures made. The flight of sounds, followed by their repetition without apparent cause, as with echoes, and their diversion from original sources, completely deceiving the listener, as shown by the art of the ventriloquist, are familiar and eloquent examples of the extraordinary behavior of sounds, which prove the necessity of aiding the ear in order to obtain correct knowledge. The noises of the engine room swell and fade away and come again as if by magic, putting you all out in your search for their source. Of course we do know that knocks in engines are as numerous in variety as the engines themselves, and that they arise from many more sources than the numbers and handling of the same. One prime source of knocking is want of alignment; for, say what we will, an engine in motion under steam is in a very different condition, with regard to its lines, from the same engine when standing. Under severe and reversed strains, every part yielding more or less to the pressure imposed, the certainty of maintained alignment is not secured, and the extent of the departure of some essential organs of the power transmission while at work, from the mathematical exactness intended, is not known till the engine speaks in tones which the intelligent engineer ought to understand and answer. Heavy oil and oil with pulverized and purified graphite, will often cushion the bearing and cure a mild knock in shafts which are acted upon by reciprocating forces. Sliding pieces of machinery frequently knock after long use, when a change of its stroke has been made by adjustment of connected parts; a shoulder has been formed and the moving part strikes it. The amount of metal in the way is often astonishingly small, as I have found by experience in cross-head guides and steam cylinders.

The ways of some knocks are well nigh past finding out, deceiving and defying the very elect. I had a case of knock in a vertical engine once that outwitted two of our best machinists. They both took the engine completely down and re-erected it, but failed to find the cause of the knock. A bystander declared the follower of the piston was loose, for he had a long hunt in his engine and found the knock at last, as he stated; therefore, it must be in the piston. But, my dear sir, there is no follower to this piston, it is a solid one with rings sprung into its peripheral grooves. Another informed me that after diligent search everywhere, as he thought, he finally discovered the crank-pin to be loose in the crank—impossible of application to our case. This engine shaft has a solid forged center crank, all in one piece. Other causes were discussed and explained away; there was certainly no precedent for the knock we had in hand. So dismissing all critics and adjusting properly all the working parts, "Now, John," I said, "let's see her run." And sure enough, there was that same unvanquished knock, occurring every time the cranks passed the top center. "Now John, run her slow — as slow as you can." We now have two knocks instead of one, at the same place in the turn. Here is something to reason out; two knocks at slow speed, one at high. What part of an engine can do that? It must be at the place where the parts under the intermitting action of the steam join the continuous running wheel; for at high speed the wheel does not outrun the shaft, but the steam is quicker than the wheel and turns the shaft ahead, pressing it against the key; in the other case, when the engine creeps, the crank will hardly pass the top center without help; but the wheel, being heavy, keeps on in rotation, crowding the key and driving the shaft over the top center; when the steam comes on it sends the shaft quickly ahead, pressing against the other side of the key. Now, if the key is not tight, these knocks can be accounted for. This mystery being cleared up, I tell John what's the matter: the fly-wheel key is loose. "Stop the engine and hit the key a tap with your hammer, please." And when we started again a quieter running engine was never seen.

You sympathize with the long-suffering engine-driver who for months can't trace the "knock" to its source, and silence it. He comforts you with his justifiable (?) remark that it has been in the engine from the first. *You*, mayhap the busy engine-builder, step in on call, hear the knock at the moment you open the door of his engine room, take up a wrench from the window sill, give a tap-bolt on the cross-head a slight twist, throttling the said knock, bid the engine room good-bye and pass out and down the street, wondering whether it is or is not included in the curriculum of the engine-man's studies and duties to seek for and to gain and to apply some knowledge of knocks — their cause and thei. remedy.—*Machinery.*

The Locomotive.

HARTFORD, MARCH 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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A FEARFUL accident occurred in the harbor of Rio Janeiro, Brazil, on January 7th. The boilers of the *Port Nictheroy* exploded, setting the steamer afire, and the excursionists who were aboard were obliged to jump into the sea to escape the flames. About 120 of them were drowned.

SOME of the would-be legislators in this broad land of ours have peculiar ideas. In one case it was proposed "to require insurance companies to insure boilers on tests made by the State!" Why not require life insurance companies to insure on examinations made by the board of health?

THE Mills block, in Patchogue, R. I., was shaken up somewhat, on February 2d, by the explosion of a vulcanizer in the office of Dr. J. R. Furman, a dentist. The room in which the vulcanizer stood was badly wrecked, and a piece of the cylinder went through a wall, carrying a set of false teeth with it.

THE Associazione fra gli Utenti di Caldaie a Vapore, of Milan, Italy, has very kindly sent us the three volumes of their reports for 1891, 1892, and 1893, and also two interesting little volumes by Chief Engineer Guido Perelli, entitled, respectively, *Instructions to Locomotive Engineers* and *Instructions to Firemen.*

WE learn with regret that the private laboratory of Mr. Nikola Tesla, the famous electrician, was destroyed by fire on March 13th. All of the apparatus that it contained was ruined, including several nearly completed inventions relating to electric lighting. Mr. Tesla feels his loss keenly, and he will have the sympathy of a wide circle of friends.

THE St. Louis *Globe-Democrat* gives another example of the antiquity of all subsolar things. "A tubular boiler 1,800 years old has been discovered in Pompeii," it says. "It is made of sheet metal, probably copper, in the shape of a large amphora, or two-handled jar, with a hollow space running half-way up the center of the jar. In this space was placed a cylindrical fire-box resting on five fire-bars, which are tubes three-quarters of an inch in diameter, connecting with the water space. The fuel seems to have been charcoal."

On January 8th, Mr. William Jackson lost his life by an accident in the boiler room of the pumping station at Selma, Ala. One of the boilers, known as the "reserve boiler," had only fifteen pounds pressure upon it, while the others in the battery had about eighty. Jackson opened the stop-valve on the "reserve boiler" too suddenly, causing the steam in the hot boilers to rush into the cooler one with great speed. Doubtless there was more or less water in the steam pipe, and it is probable that some sort of a water-hammer action resulted. At all events, the stop-valve at which Jackson was standing burst, and the unfortunate man was killed instantly. His skull was fractured, and he was terribly scalded. This accident is only one of a large number of the same sort, which are continually occurring. It ought to emphasize, strongly, the danger of opening a stop-valve suddenly.

We read of another one of those black conspiracies to blow up boilers, this time in an esteemed western contemporary. "The timely discovery by an engineer that something was wrong with the boiler in a planing mill this morning," says the account, "prevented a disastrous explosion. During the night water was removed from the boiler under which was banked a fire, causing the burning of the plates, the plotters contemplating an explosion when water was turned on to the dry boiler after the fire was made. The belt used to move the machinery had been cut, and every preparation made for the dare-devil exploit." Our esteemed contemporary does not explain why the dare-devil exploiters cut the belt, if they "contemplated an explosion when water was turned on to the dry boiler;" nor does it furnish a certificate that the blow-off was shut tight the night before when the fireman got through with it.

Boiler Explosions and Dynamite.

The recent terrible boiler explosion at Mendota, Ill., (see No. 22 in the list of January explosions in this issue) was of such extreme violence that many of those who viewed the ruins found it hard to believe that such havoc could be wrought by a steam boiler. The senior member of the firm owning the boiler said at the inquest that "he did not believe the disaster was caused by the bursting of a boiler," because he thought such an explanation inadequate. Another member of the firm "believed that the disaster was caused by dynamite." He did not believe that the heavy ice engine, weighing upward of twenty tons, could have been completely overturned, anchorage and all, and then shattered to pieces simply by the explosion of either of the boilers; also that the ground would not have been rent by a boiler explosion, *which has an upward tendency.* He is borne out in this opinion by two expert boiler inspectors from Chicago and one from La Salle, "who have been at work upon the matter the last two days." "Some of the facts discovered by the latter," the same account continues, "have created a decided sensation. Mr. Henning would not state whether he thought the dynamite was placed in the brewery by designing persons, or whether it might have been some that was being used by the well diggers."

There is a dark hint here of a mysterious plot against the property of the owners of the brewery and the lives of the unfortunate victims of the explosion; but there was no basis whatever for such an insinuation, except that a great amount of damage was done. (The coroner's jury rightly took this view of the case.) An exploding boiler is a terrible engine of destruction, and quite competent to do as much damage as a reasonable quantity of dynamite can do. In fact, we never hear of dynamite theories except from persons unfamiliar with the dreadful possibilities of boiler explosions. Of course, the italicised reference to the *direction* of such explosions has no basis of fact. It is bad physics, and there is no evidence to support it.

The New Element, "Argon."

In THE LOCOMOTIVE for July, 1893, we published the contents of a circular issued by the Smithsonian Institution to the scientists of the world. In this circular various prizes, known as the "Hodgkins Fund Prizes," were offered for treatises and essays upon atmospheric air. The principal offer was "a prize of $10,000 for a treatise embodying some new and important discovery in regard to the nature or properties" of air. The time-limit for this treatise expired on December 31, 1894. We do not know that the prize has yet been formally granted, but there is no doubt that it will ultimately be awarded to Lord Rayleigh and Professor Ramsay, who have discovered that a remarkable and hitherto unknown gaseous substance, which they call "argon," forms a constant constituent of the air.

The history of the discovery of argon is very interesting. Several years ago Lord Rayleigh, in the course of some experiments on nitrogen, observed that the density of that gas is greater when it is obtained from the air than it is when obtained from nitrogenous compounds. After satisfying himself that the difference in density was real, he proceeded to investigate its cause. Naturally enough, he suspected that there might be an unknown "allotropic form" of the gas present, either in the air or in the supply obtained by chemical means. This explanation appeared the more probable, inasmuch as a number of the other elements that occur in organic bodies have allotropic forms — for example, oxygen, carbon, sulphur, and phosphorus. This point was tested by methods that we cannot discuss in the present article, and the results were negative — the difference in density did not appear to be due to allotropism. It was next thought possible that the "chemical" nitrogen was contaminated with traces of hydrogen, some slight amount of that gas coming through the purifiers in which any of it that might be present was supposed to be absorbed. To test this point, hydrogen was purposely added to the "atmospheric" nitrogen, and the mixture was run through the same purifiers. The absorption of the hydrogen was perfect, the density of the nitrogen returning precisely to the original value. This indicated that the lightness of "chemical" nitrogen is not due to the accidental presence of slight quantities of hydrogen. Various other possible explanations of the difference in density were examined, but always with negative results. Finally, a considerable quantity of "atmospheric" nitrogen was brought in contact with red-hot magnesium, the result being that the greater part of the gas united with the metal to form a nitride; but there was always a small residue of gas left, which could not be made to combine with the magnesium. When the residue so obtained from a considerable quantity of "atmospheric" nitrogen was collected in a glass tube and examined by passing electric sparks through it before a spectroscope, it was seen at once to be quite different from nitrogen. Its spectrum was unlike that of any other known body.

As soon as the new gas had been isolated, great interest was aroused in the scientific world to know whether or not it was an *element*. To determine this question attempts were made to cause the gas to combine with something; but, so far as we are aware, every experiment of this kind has utterly failed, and the new substance appears to possess the unique property of being well enough satisfied with itself, and unwilling to combine with any other body, under any circumstances whatever. In this respect it is diametrically opposed to fluorine, which is by far the most ready of all the elements to form compounds with other substances. The atomic weight of the new gas is thought to be about 40. This is only inferred from the density of the gas, however, and nothing certain can be learned about the atomic weight until chemists have succeeded in inducing the gas to combine with something.

Among the various physical properties of "argon" that have been determined is the ratio that its specific heat at constant pressure bears to its specific heat at constant volume. We do not know the precise value that has been obtained for this ratio, but we understand that it is in the neighborhood of 1⅔. Now, it is known from the kinetic theory of gases that if the ratio of the specific heats is as great as this, the molecules of the gas must be extremely simple. It is upon this fact, combined with the character of the spectrum of the gas, that the belief in the elementary nature of "argon" is based.

In conclusion, we must say that, although Lord Rayleigh first observed the discrepancy in the density of nitrogen as obtained from different sources, the prestige of the discovery of "argon" does not rest with him alone. Professor Ramsay has also given great attention to the problem, and the two experimenters succeeded in isolating the new gas at almost exactly the same time, and by the same method. The present plan is, we believe, to divide the honor between the two men, and let their names be both handed down to posterity with equal distinction.

Margins of Safety in American Boiler Practice.

The following quotation from our esteemed English contemporary, the *Practical Engineer*, should be of interest to all our readers:

"Allowable steam pressures in America are generally understood to be very much in excess of anything allowed in this country, but we are not aware that anything has ever been published here showing to what extent there is foundation for this belief. It may be stated that pressures are based very much upon the Rules and Regulations of the Board of Supervising Inspectors of Steam Vessels, which are set forth in a pamphlet known as 'Form 2101,' and in this are very fully set forth the pressures that may be used for both boiler shells and flues. To a certain extent, boiler pressures are upon a more certain basis than with ourselves. American boiler plate is stamped by its makers with its ultimate tenacity in pounds per square inch of section, and, according to this stamping, a boiler is allowed a corresponding steam pressure. Should plates not prove when tested to be of the strength stamped upon them, they may be re-stamped to the figure found by the testing inspector. In addition to strength, steel plates must elongate 20 per cent. in a length of 8 in.

"The tables of allowable pressures that are printed in Form 2101 include shells from 36 in. to 96 in. diameter, increasing by 2 in. up to 48 in., and by 6 in. for the remainder. The plate thicknesses are given from .1875 in. to .375 in., increasing by no special rule as follows: .21, .23, .25, .26, .29, .3125, .33, .35 — in all, ten thicknesses. Taking a shell of 84 in. diameter and ⅜ in. thick, we find that for plates of 45,000 lbs. tensile strength the pressure for single riveting is 66.96 lbs., and for double riveting it is 20 per cent. higher, or 80.35 lbs. Now, as the 45,000 quality is about equal to 20-ton iron, we may compare this final figure with the allowance for a 7 ft. double-riveted Lancashire boiler of ⅜ in. plate — *viz.*, 65 lbs. at the most — and we see that American practice allows a little higher pressure upon a single-riveted shell than English practice allows for double riveting. The rule is given thus: 'Multiply one-sixth of the lowest tensile strength found stamped on any plate 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 sum [quotient] will be the pressure allowable per square inch of surface for single riveting, to which add 20 per cent. for double riveting.' The allowance for hydrostatic pressure test is 50 per cent. additional — quite enough, too, for it gives a test pressure higher than the very usual English test, which prescribes 75 per cent. addition to the working pressure.

"Some few years ago — the rule was in force to the writer's knowledge in 1887, but has since been repealed — there was a special pressure allowance for the boilers of freight and towing steamers on the Mississippi River and its tributaries, and under this rule the pressures allowed were most alarming. Thus, taking the example of the 84 in. shell, $\frac{3}{8}$ in. thick, the rules would give $112\frac{1}{2}$ lbs., the standard pressure being 150 lb. on a 42-in. shell, $\frac{1}{4}$ in. thick; and we are not even enlightened as to whether the riveting is other than single; neither are we told why the Mississippi River is so specially favored in the matter of pressure.

"With such facts as these officially before us, need we wonder at the frequency of American boiler explosions? Rather, should we not be surprised that there are so few?

"Presumably, this Mississippi law being repealed, all boilers are on the same footing; but we believe that American boiler insurance companies have to contend against the excessive pressure of boilers thus fostered by the government itself. Curiously enough, too, in some cities of America — New York, for example — the inspection of boilers is undertaken by the municipal authorities as a police function; but we believe that this resolves itself into little more than an application of the hydraulic test, in a manner far removed from what safety would dictate. Speaking generally, then, we should say that steam pressures are excessive, and we should not omit to emphasize that for higher qualities of steel the pressure allowed is correspondingly increased, so that for steel of 70,000 lb. tensile resistance the 7 ft. boiler, only $\frac{3}{8}$ in. thick, and double riveted, is allowed to carry 125 lb., single butt strips must be as thick as the plates, and double strips not less than $\frac{5}{8}$ of the plate thickness. Braces and stays must not be stressed beyond 6,000 lb. per inch of section, unless of steel specially tested, when they may even be allowed 9,000 lb. on their smallest section.

"Tubes for external pressure seem to have equally heavy pressures allowed. Thus, a 40 in. lap-welded or riveted tube, $\frac{1}{2}$ in. thick, in sections of 30 in. in length, is allowed 107 lb. pressure, which seems heavy, though for corrugated flues the rule is $\frac{14000\ t}{D}$, which would give the pressure of 175 lb. to a 40 in. flue of half plate. It is difficult to realize that with such excessive pressures as we have quoted plain flues and shells can endure long. We believe that the Hartford Steam Boiler Inspection and Insurance Company has for a long time been adverse to such dangerously heavy pressures, but with the weight of government authority against them, no doubt they find it difficult to effect very much. Probably our English practice borders on the over-cautious. Certainly it has practically abolished boiler explosions, and English steam-users send boilers to the old boiler yard which would be granted certificates in America for a pressure in excess of what they were permitted to bear when brand new in England. With such facts before us, we can no longer wonder at the compound explosions such as that of Shamokin. In a heavily-stressed shell, a very small extra provocation may easily lead to an explosion."

We do not propose to discuss this question of comparative practice at all exhaustively at present, but we must call attention to one or two things that are suggested by the most superficial perusal of the foregoing article. In the first place, it is obviously wrong to compute an "allowable pressure" with no further knowledge of the joint than that it is single-riveted or double-riveted, as the case may be. We have striven for many years to fix this point in the public mind, and it is only fair to say that we have met with some considerable success — though there is still room for many more sermons on the same text. Every one who has had a wide experience with the joints that are put into boilers will know that a poor double-riveted joint is often far inferior in strength to a good single-riveted one; and before deciding what pressure shall be allowed, it is certainly imperative to know the proportions of the joint, and its efficiency. Any rule that does not take these things into account is misleading, and, in many cases, exceedingly dangerous.

Another point that we wish to consider is that the rules established by the United States government do not apply to boilers in general, but only to such as are subject to government inspection — that is, chiefly to *marine* boilers. We are not aware that the proportion of marine boilers that explode is larger in this country than elsewhere, and hence we are inclined to question the validity of the deduction that our contemporary draws with respect to the relative total number of boiler explosions in this country and in England. Most of the boilers that explode in the United States are land boilers, to which the government rules do not apply; and in many cases of marine explosions it is easy to show that the disaster is not due to the imperfection of the government rule, but to other causes that are usually not hard to find. See, for example, the account of the explosion of the *Rambler's* boiler, in THE LOCOMOTIVE for July, 1894.

We heartily agree with the *Practical Engineer*, however, that many boilers are run in this country with too small a factor of safety. We believe that 5 is the proper factor for shells exposed to the fire; but we know that many boilers are running with a factor of not over 3½, and we believe that the wonder is, as our contemporary says, not that there are so *many* explosions, but that there are so *few*. Knowing, as we do, the conditions prevailing in boiler practice, we do not understand why more boilers are not blowing up every minute.

WE have received from the Yorkshire Boiler Insurance and Steam Users' Company, Limited, of Bradford, Eng., a copy of Chief Engineer Waugh's report on an explosion that recently occurred in Staffordshire. The manhole had presumably been leaking; at all events, the boiler attendant was screwing up the nuts on the two main bolts at the time the accident occurred, and the result was that a great strain was thrown upon the internal flange that held the cover. The failure occurred by the stripping of this flange, the remaining part of the cover being blown bodily out. The attendant was killed. The report says that calculation showed the cover to be strong enough to withstand any steam pressure that could come upon it, as well as any reasonable additional strain from the screwing up of the nuts. "The inquiry has resulted in a consensus of opinion that cast-iron is not a suitable metal for the purpose, and the object of printing this report is to make it known to steam users that it would be better to have all cast-iron manhole covers in use replaced by either wrought-iron or cast-steel ones."

The Hartford Steam Boiler Inspection and Insurance Company has long strenuously advocated the use of wrought-iron or steel, both for manhole covers and for the frames.

The Locomotive.

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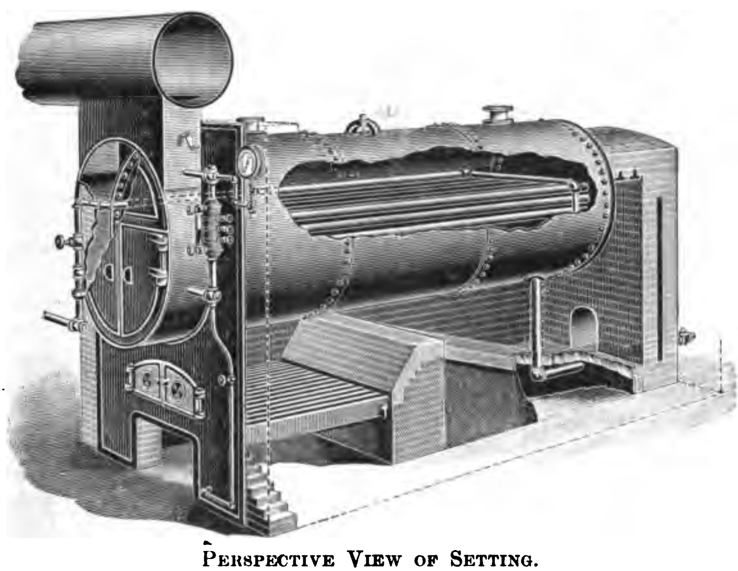
Boiler Settings.

The article on boiler settings published in the February issue of THE LOCOMOTIVE having aroused a considerable interest among our readers, and elicited a number of letters of inquiry concerning various points not touched upon in that place, we present herewith a perspective view of the setting advocated by this company, in the hope that it may make the general design somewhat clearer to those not familiar with mechanical drawings. (The side wall of the setting is supposed to be removed, in order to expose the other parts to view.)

The boiler here shown has an "overhanging front"; that is, the dry sheet projects



PERSPECTIVE VIEW OF SETTING.

outward beyond the cast-iron front-piece of the setting. We prefer this style of front because there is no possibility of burning the dry sheet. Others prefer the "flush front," urging that some heating surface is lost by setting the boiler as here shown, and that the projecting front is in the way of the fireman. We do not consider these objections to be very weighty, but we are quite ready to admit that flush-front boilers work well when the setting is properly designed and built, and we make specifications for them when our patrons prefer them. (The different forms of boiler-fronts in common use will be found illustrated in THE LOCOMOTIVE for September and December, 1890.)

The boiler itself consists of three rings of plates. In some cases, when the boiler is long, it may be necessary to use four rings, but in most cases three will be quite sufficient. The longitudinal joints, which are not shown in the engraving, should be high enough up to be entirely outside of the furnace; and the design and proportions of these joints should be carefully considered in connection with the pressure that it is desired to carry. The weight of the boiler is borne upon lugs riveted to the shell. The lugs are not shown in the present cut, but are indicated in the illustration given in the February issue. Three pairs of lugs are often provided, but we believe that two pairs are quite sufficient except when the boiler is very long; and two pairs can be brought to a good bearing more readily than a larger number can. The boiler should be "anchored" by the front pair of lugs, and the rear pair should be provided with rollers so that the boiler may expand and contract freely, without producing strains in the setting or in itself.

The course of the feed-pipe is indicated quite plainly in the engraving. If there are several boilers set in a battery, the main feed-pipe runs along the fronts, just under the projecting ends of the boilers. From this main feed-pipe a branch pipe is taken off for each boiler. The branch pipe is taken off on the left-hand side of the boiler, and near the main pipe it is provided with a ground union, or with a flanged connection. Immediately above the union there is a check-valve, and above this is the globe valve which controls the feed. The feed-pipe rises until just above the level of the tubes, when it turns to the right and enters the front connection as shown. It then turns again and enters the boiler just inside the root of the flange of the head, and passes down the boiler on the inside, nearly to the back end. It then crosses over to the right-hand side and discharges downward between the tubes and the shell. It is found by experience that when the feed is introduced in this way it becomes heated almost to the temperature of the water in the boiler before it is discharged, so that the annoying and often dangerous effects that are produced when the shell is chilled by cooler feed-water are entirely avoided. In many parts of the country, where the water used in the boilers is muddy, some form of top feed is often preferred. We have no objection to the top feed when it is properly designed and constructed. (A form that has been found to work well is shown in THE LOCOMOTIVE for March, 1891.) On boilers 60 inches or more in diameter the diameter of the feed-pipe should be at least 1½ inches. On boilers 36 inches in diameter, or less, the feed-pipe should be at least one inch in diameter. On boilers of intermediate sizes — say from 42" to 54" inclusive — the feed should not be less than 1¼ inches in diameter.

The blow-off pipe should be located at the rear end of the boiler, as shown in the illustration. It is very important that the shell should be *reinforced* where the blow-off enters it. The neglect of this precaution has led to many serious accidents. As the blow-off is exposed to the action of the fire, it is also highly important that it should be encased in a protecting sleeve of some kind, as indicated by the dotted lines. A piece of larger pipe, slipped over the blow-off, is frequently used for this purpose. An asbestos rope, coiled about the blow-pipe, is also satisfactory; and in THE LOCOMOTIVE for September, 1891, a special form of cast-iron sleeve is shown, which has certain advantages over either of these devices. The blow-off pipe is often so arranged that the elbow comes in the combustion chamber; but we believe that this is bad practice, and we strongly recommend that it be carried straight down until it passes below the floor of this chamber. The elbow is then well protected from the fire, and the horizontal portion of the blow-off passes out through the rear wall of the setting, under the center of the cleaning door, as shown. The blow-off pipe should be 2" in diameter under ordinary circumstances, but where the water is bad 2½" may prove to be a better size, and in some rare cases it may advantageously be as large as 3″. It is important that there should be a very rapid discharge through the blow-pipe when the cock is open, in order that fragments of scale or other obstructions may be swept out with certainty. If the pipe is larger than we have indicated above, it is difficult to realize this effect. Plug cocks or gate valves should always be used on blow-off pipes; globe valves are very apt to trap pieces of scale. (This point was discussed in THE LOCOMOTIVE for October, 1894.)

We recommend the use of a water-column of some kind. The chamber of the column should be at least four inches in diameter internally, and the pipes by which it is connected to the boiler should not be less than 1¼ inches in diameter. We also recommend that the connections used in attaching the water-column should be *four-way tees* instead of elbows. It will then be possible to clean the connections out thoroughly by removing the plugs in these tees, and running a straight rod of suitable diameter through the piping. A small drain-pipe should be provided at the lowest point of the water-column attachment, in order that sediment may be blown out readily. It is convenient to have this drain-pipe discharge into the ash-pit, as shown in the engraving. The try-cocks and gauge-glass are attached to the water-column, and the lowest try-cock must be at least three or four inches higher than the upper side of the top row of tubes. The steam-gauge is attached to the steam connection of the water-column. It must be provided with some form of water trap, in order that the hot steam from the boiler may not come in contact with the Bourdon spring. If this is not attended to the gauge will not give correct readings, and it is very likely to be entirely ruined. The requisite water trap is commonly provided by forming the steam-gauge pipe into a U, or by bending it around an entire circle. This form of trap is objectionable, because although it performs its function perfectly when everything is in proper condition, it can be cleaned out only with great difficulty. As there is little or no circulation in the water-trap, sediment, carried over by particles of water in the steam, or in some other manner, is liable to lodge in it, and we often find gauge-connections entirely stopped up from this cause. It is much better to attach the gauge by means of nipples and fittings, as shown in the engraving. In case of choking, it is then easy to take the trap apart and clean it thoroughly. A small cock should always be provided at the lowest point of the trap, so that the fireman can readily draw the water off when the boiler is put out of service.

Inspectors' Report.

FEBRUARY, 1895.

During this month our inspectors made 7,131 inspection trips, visited 14,576 boilers, inspected 3,991 both internally and externally, and subjected 414 to hydrostatic pressure. The whole number of defects reported reached 9,892, of which 1,297 were considered dangerous; 66 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	768	48
Cases of incrustation and scale,	1,453	65
Cases of internal grooving,	70	17
Cases of internal corrosion,	413	41
Cases of external corrosion,	642	61
Broken and loose braces and stays,	111	23

Nature of Defects.	Whole Number.	Dangerous.
Settings defective,	250	23
Furnaces out of shape,	389	15
Fractured plates,	251	63
Burned plates,	245	30
Blistered plates,	142	7
Cases of defective riveting,	1,420	35
Defective heads,	84	16
Serious leakage around tube ends,	1,866	571
Serious leakage at seams,	496	42
Defective water-gauges,	418	72
Defective blow-offs,	158	43
Cases of deficiency of water,	27	5
Safety-valves overloaded,	74	31
Safety-valves defective in construction,	86	49
Pressure-gauges defective,	414	39
Boilers without pressure-gauges,	1	1
Unclassified defects,	114	0
Total,	9,892	1,297

Boiler Explosions.

FEBRUARY, 1895.

(30.)— A boiler exploded, on February 1st, at the electric light company's plant at Washington, Tazewell County, Ill. The building was totally wrecked, and the machinery was ruined. Five men were in the building at the time. Berry Huddlestone was fatally injured, and Daniel Donahue, Isaac Macdonald, Isaac Holland, and William Sopenbaugh were also injured more or less seriously. One large section of the boiler was blown nearly half a mile. Two adjacent buildings caught fire, but the flames were subdued before much damage resulted.

(31.)— A boiler exploded at Reeves's mill, Duck Hill, Miss., on February 1st, killing a man named Newell, and breaking both of Reeves's leg, and injuring him otherwise.

(32.)— A steam-heating boiler exploded, on February 3d, in one of William J. Snow's greenhouses, at Waterbury, Conn. Jacob Snyder, who was in charge of the boilers, was painfully scalded. One of the greenhouses was demolished, and Mr. Snow's loss is estimated at $1,000.

(33.) — One of the boilers in Gray Bros.' factory, at Muskegon Heights, Mich., exploded on February 3d. The boiler-house, engine-room, and dry kiln were wrecked. John Thompson, the watchman, was blown through a twelve-inch brick wall and instantly killed. The property loss is variously estimated at from $4,000 to $12,000.

(34.)— On February 3d a boiler exploded at the Cincinnati Ice Company's plant, at Amanda, near Hamilton, Ohio. There were but 30 pounds of steam on the boiler at the time, and the fire had gone out. Nobody was hurt.

(35.)— A heating boiler exploded, on February 4th, in the residence of H. R. Bowlen, at Canton, Ohio. The Cleveland *Press* says that "the explosion tore out the brick chimney, broke every pane of glass in the house, and knocked three doors off their hinges. Furniture and carpets worth $500 were ruined. Two ladies heard the noise, and ran from the kitchen, barely escaping the dining-room door, which came flying after them. Four persons were in the house, but the only fatality was the killing of the house cat."

(36.)—Another heating boiler exploded, on February 4th, in the residence of Mrs. W. H. Hopkins, Baltimore, Md. A slight fire ensued. The adjoining house, belonging to H. M. Clabaugh, was also slightly damaged.

(37.)—Charles Miller was badly injured, on February 4th, by the explosion of a boiler in Muncie, Ind. The boiler was heated by natural gas, and the owner, John W. Schaffer, had turned the gas very low upon leaving the boiler at night. About ten o'clock young Miller turned it on again to warm himself, and it is supposed that he forgot it and fell asleep. Schaffer's property loss will be small.

(38.)—William Routt was badly scalded, on February 4th, by a boiler explosion at Milford, near Augusta, Ky.

(39.)—A boiler exploded, on February 4th, at Carpenter's Ice House, Providence, R. I. Patrick Hehir and John Hehir were killed instantly, Martin Deery died within an hour, and William Morton died shortly afterwards. The others who were injured are Herbert Smith, Thomas Casey, Charles Brayton, Thomas Nelson, Martin Ryan, Henry Butler, Philip Lynch, Michael Tierny, and George M. Downing. At last accounts Casey was very low, and was not expected to live. The other wounded men are doing well. A considerable amount of damage was done. The engine was blown high into the air, and landed some 400 feet from its original position. It crashed through 13 inches of ice, and now lies at the bottom of the pond.

(40.)—A heating boiler exploded, on February 6th, in the residence of Mrs. E. C. Homans, New York city. "The explosion dismantled almost every room in the five-story structure, and created sad havoc with the costly furniture and elegant decorations. Fortunately, not one member of the household was injured, though one of the servants (the porter) had a narrow escape. . . . . Every gas and water pipe throughout the building was either burst, torn, or twisted, so as to be rendered useless. The stairway was split up the middle, while supporting iron columns on the various floors were badly bent. . . . The hall doors, massive and elegant in their construction, were torn from their hinges and blown into the hall. . . . Nothing was left of the boiler, save small bits of iron." A slight fire ensued, which did about $100 damage. The property loss due to the explosion itself is estimated at $10,000.

(41.)—A heating boiler exploded in St. Patrick's Church, at Fort Hamilton, N. Y., on February 6th. We have not seen an estimate of the damage.

(42.)—On February 6th a heating boiler exploded in the basement of the West Side Public School, at Elyria, Ohio, during the noon recess. The northern wall of the building was blown out, and a fire resulted, which did much damage. Had the explosion occurred fifteen minutes later, when the 200 children had returned, a frightful loss of life would have occurred. The damage to property is variously estimated at from $7,000 to $14,000.

(43.)—A boiler exploded, on February 6th, in the Frontier House, Niagara Falls, N. Y. We have not received particulars.

(44.) — A locomotive boiler exploded, on February 6th, at Curve, a station on the New River Division of the Norfolk & Western Railroad (Virginia). Engineer John King was thrown a long distance, and injured so badly that he died about an hour later. Fireman Dean Henry was killed instantly.

(45.) — A heating boiler exploded, on February 7th, in a Wagner sleeping car at Huron, S. D. The car, which was side-tracked at the time, was wrecked.

(46.) — A heating boiler exploded, on February 7th, at the drill hall of the Academy, at Highland Park, near Waukegan, Ill. Considerable damage was done, but nobody was injured.

(47.) — The boiler of the steam laundry at El Paso, Tex., exploded on February 7th. W. A. Williams and Geronimo Ortiz were killed. W. C. Harvie, the proprietor, was fearfully scalded and bruised, and will probably die. Juan Obrebos will also die. Hillario Sierra, the fireman, was slightly injured. A section of the boiler, weighing a hundred pounds or so, fell through the roof of Coffin & Seeton's grain warehouse, two blocks away. Another section crashed into the Sheldon dining-room, still further away. Burge's art parlors, situated near the laundry, were badly damaged.

(48.) — A new boiler, used for heating Nathan & Son's store at Lancaster, Wis., exploded on February 7th, doing a great deal of damage. John Stephens, William Benn, and Arthur Benn were also scalded more or less severely, but not dangerously.

(49.) — A section of the heating boiler in the High School at Duluth, Minn., exploded on February 8th. The damage was not great, and nobody was injured.

(50.) — A boiler exploded on the steamer *Cyclone*, on February 8th, while she was steaming down the St. Francis river, some four miles east of Forest City, Arkansas. We have not learned particulars.

(51.) — A boiler exploded at an oil well in Brownsdale, Pa., on February 9th. William Williams, a driller, was killed.

(52.) — A heating boiler exploded on February 12th in the High School building at Shamokin, Pa. Fortunately nobody was injured.

(53.) — A boiler explosion occurred at Crockett, Houston county, Tex., on February 12th. We have been unable to obtain details, beyond the fact that nobody was injured.

(54.) — A rotary bleaching boiler exploded on February 12th, at the works of the American Straw Board Company, at South Kenton, Ohio. Isaac Schooler was seriously and perhaps fatally injured. The loss of property was estimated at from $1,000 to $2,000.

(55.) — On February 12th, a boiler exploded in Martin & Dreibholz's mill at Bay Ramos, La. One man was killed and several others injured. The property loss was about $15,000.

(56.) — A boiler exploded at the Spencer Coal Company's colliery at Dunmore, near Scranton, Pa., on February 14th. Fireman Reuben Jones was terribly burned and scalded.

(57.) — A slight boiler explosion occurred on February 14th, in the woolen mills at Lisbon, Ohio. Nobody was near the boiler at the time, and there were no personal injuries. The property loss was small.

(58.) — A boiler exploded on February 15th, in the rear of Deibel's meat market, at Youngstown, Ohio. The building was wrecked and John Price, Albert Apple, and M. L. Cook were badly scalded.

(59.) — A boiler in Conklin & Peterson's lumber mill at Lumberton, eight miles south of Xenia, Ohio, exploded on February 15th, killing Howard Street instantly. Street was the only person in the building at the time of the explosion.

(60.) — On February 15th, a boiler exploded in the Cobb saw mill, near Towanda, Pa. Theodore Pencil and John Mack were instantly killed, and Frank Myers was fatally injured. The mill was completely wrecked, and everything in the vicinity was destroyed.

(61.) — The boiler at Gilbert Bryant's slaughter house, at Parkersburg, W. Va., exploded on February 15th, "tearing the building into kindlings." The boiler alighted in a field, several hundred yards away. Charles Bryant was caught under some of the falling timbers, but was not dangerously hurt.

(62.) — A boiler exploded on February 16th, at Holloway's oil lease, about eight miles from Bradford, Pa. James Frazier and Alfred McQuiston were killed.

(63.) — A slight boiler explosion occurred on February 16th, in a roller mill at Campbell, Hunt county, Tex. Mrs. J. M. Reily and her two little daughters were seriously scalded. They will recover.

(64.) — A boiler exploded in Prime's shoe factory, in Rowley, Mass., on February 18th. The explosion is said to be due to the weakening of the boiler by corrosion. Nobody was injured.

(65.) — On February 18th a heating boiler exploded at the Spring Valley Water Company's plant, San Francisco, Cal. R. J. Sweeney, J. G. McKenzie, and John Taylor were injured. The damage to property was not great.

(66.) — A boiler exploded at the Emery Candle Works, Cincinnati, Ohio, on February 19th.

(67.) — A boiler explosion occurred on February 19th, in the elevator of J. G. & J. P. McCord, at McCordsville, near Scranton, Pa. The engine and boiler room were completely wrecked. The accident happened at the noon hour, and nobody was hurt.

(68.) — A small hot-water boiler exploded on February 19th, in C. E. Hornberger's drug store, Providence, R. I.

(69.) — A locomotive boiler exploded on the New York & New England railroad, near Danbury, Conn., on February 21st. Alfred Deitweiler, the fireman, was blown from the cab into a snow-bank. He was badly scalded. The engineer escaped unhurt. The train was running at about fifteen miles an hour when the explosion occurred.

(70.) — A small boiler exploded on February 21, in John F. Smith's wood shop, at Biddeford, Me. Nobody was injured, but the property loss will amount to about $1,000.

(71.) — A tube collapsed on February 22d, in the boiler of a freight engine on the Chicago & Grand Trunk railroad, near Imlay City, Mich. Timothy McCarthy, the head brakeman, was fearfully scalded, but it is believed that he will recover. The engineer and fireman were slightly injured also.

(72.) — On February 25th, a boiler exploded in John J. McLaughlin's mineral and aerated water factory, at Toronto, Ont. "The whole front of the substantial, double-fronted two-story brick and stone building fell outward, and, with the roof and a portion of the walls, scattered into an indescribable wreck of dèbris across the entire roadway; while the remainder of the structure collapsed on either side, until scarcely one stone was left upon another." The property loss probably exceeds $10,000.

(73.) — A saw-mill boiler exploded on February 26th, at Adelphi, fifteen miles from Chillicothe, Ohio. The mill was operated by Jacob Weltz and his two sons, Curtis and William. Both of the sons were fatally injured, and died within a short time. The father escaped without injury.

(74.) — Oliver Lockwood and Albert Dougherty were fatally scalded, on February 25th, by the explosion of a boiler in the Nottingham township oil field, near Portland, Ind.

(75.) — A boiler exploded on February 27th, at Clark & Cowles's factory, Plainville, Conn. Nobody was injured, and the damage to property was slight.

Boiler Explosions during 1893 and 1894.

It has been our custom, until recently, to give, each year, a summary of the boiler explosions of the year before. This practice was discontinued in 1894, for it seemed doubtful if such summaries were of sufficient interest to our readers to require publication. We have recently received a number of letters, however, asking for the number of explosions, and for the number of killed and injured, during the past two years, and we therefore present this information in the accompanying tables.

The total number of explosions in 1894 was 362, against 316 in 1893, 269 in 1892, and 257 in 1891. In some cases more than one boiler has exploded at the same time. When this has happened, we have counted each boiler separately, as heretofore, believing that in this way a fairer idea of the amount of damage may be had.

SUMMARY OF BOILER EXPLOSIONS FOR 1893.

MONTH.	Number of Explosions.	Persons Killed.	Persons Injured.	Total.
January,	39	29	42	71
February,	29	20	35	55
March,	26	35	30	65
April,	28	29	31	60
May,	23	37	36	73
June,	14	9	13	22
July,	18	17	17	34
August,	29	43	34	77
September,	22	28	26	54
October,	29	22	36	58
November,	33	33	49	82
December,	26	25	36	61
Totals,	316	327	385	712

The number of persons killed in 1894 was 331, against 327 in 1893, 298 in 1892, and 263 in 1891; and the number of persons injured in 1894 was 472, against 385 in 1893, 442 in 1892, and 371 in 1891.

The greatest explosion of the year 1894 — the greatest, in fact, that has ever occurred, so far as the *number* of the bursting boilers is concerned — occurred at Shamokin, Pa., on October 11th, and was illustrated and described in our issue of last December. In this great disaster twenty-seven boilers exploded simultaneously, six persons were killed, and three others were injured.

SUMMARY OF BOILER EXPLOSIONS FOR 1894.

MONTH.	Number of Explosions.	Persons Killed.	Persons Injured.	Total.
January,	30	27	39	66
February,	26	24	27	51
March,	20	19	34	53
April,	23	32	36	68
May,	22	22	42	64
June,	22	22	20	42
July,	25	28	12	40
August,	37	37	54	91
September,	28	35	48	83
October,	62	35	55	90
November,	39	18	51	69
December,	28	32	54	86
Totals,	362	331	472	803

It is difficult to make out accurate lists of explosions, because the accounts of them that we receive are often unsatisfactory. We have spared no pains, however, to make these summaries as nearly correct as possible, and in some cases we have gone over as many as eighty accounts of a single explosion, in order to extract such information as we could concerning the injuries and the loss of life involved. It may be well to add, too, that these summaries do not pretend to include *all* the explosions of 1893 and 1894. In fact, it is probable that only a fraction of these explosions is here represented. Many accidents have doubtless happened that were not considered by the press to be sufficiently "newsy" to interest the general public; and many others, without doubt, have been reported in local papers that we do not see. Our country is big, and it is hard to keep it all under the editorial eye.

BY an unfortunate typographical error, the "Inspectors' Report" given in our March issue was stated to be the report for *March*, 1895. It should have been headed *January*, 1895.

PROFESSOR E. E. Barnard, of the Lick Observatory, reports that the "new star" in the constellation *Auriga* is still visible, though very faint, and that it has not changed in physical appearance since the autumn of 1892. It remains perfectly stationary with reference to the neighboring faint stars that surround it.

The Locomotive.

HARTFORD, APRIL 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

A BOILER in a distillery at Itzkany, Roumania, exploded on March 3d, doing great damage to the building and causing a loss of twelve lives. One workman, who was sleeping in a room over the boiler, fell into a tank of spirits and was shockingly scalded and burned.

Two boilers in the new addition to the American Tin Plate Factory, at Elwood, Ind., were blown up by a natural gas explosion on February 24th. The boilers were thrown from their settings, and the surrounding walls and machinery were considerably damaged. Nobody was injured, but about 200 men were temporarily thrown out of work.

As we have to rely upon the newspapers, to a large extent, for the details that we present in our regular monthly lists of boiler explosions, it occasionally happens that we do not get the facts correctly; though in every case we do the best we can. These remarks are elicted by a note we have received from Mr. Savage, a United States inspector in Boston, concerning an explosion that is alleged to have occurred on the tug-boat *Sam'l Little* on October 24, 1894. (See THE LOCOMOTIVE for December, page 184, explosion No. 258.) Mr. Savage informs us that there was no such explosion, and that the report probably originated from the fact that there was a slight fire forward, which was put out by one of the deck hands.

We make the correction with pleasure.

Kitchen Explosions in February.

A considerable number of explosions of kitchen boilers and water-backs occurred during the cold snap in the early part of February. These domestic explosions are rarely mentioned in the papers; but in a single issue of the New York *Herald* (that of February 7th) we find mention of no less than five, which all occurred on the morning of the day before. Mr. S. Garnett, of Brooklyn, N. Y., was one of the victims. The water-back in his kitchen stove burst, and the entire front of the stove was blown out. A blaze followed, but it was extinguished without much trouble. Nobody hurt. A similar accident happened in Mr. John Campbell's residence, on Raymond street, New York. The damage done at this place is estimated at $150. Another water-back burst in Mrs. O'Brien's house, on Belmont avenue, demolishing the stove and damaging a considerable amount of furniture. A more serious accident of the same nature occurred in Mr. William Fitzgerald's residence, on Washington Avenue. Owing to the intense cold Mr. and Mrs. Fitzgerald ate breakfast in the kitchen. During the meal the water-back burst, blowing the stove to pieces and throwing boiling water and fragments of iron all over the room. Mr. Fitzgerald was struck about the head and painfully injured. His wife, who was nearer the stove, and who therefore fared much worse, was very badly scalded. A still more serious explosion occurred on Garside street, Newark, N. J., in the home of Mr. and Mrs. Jacob Searing. Mrs. Searing, who is 75 years old, noticed steam coming from the water-back, and was leaning over it to see what was the matter when it exploded with extreme violence, blowing the stove to fragments, and scattering live coals all about. Mrs. Searing was badly scalded, and her clothing also took fire, and she was terribly burned. It was thought that she could not live. The damage to the house amounted to about $250.

Similar reports come from various parts of the country. Toronto was visited on February 6th by a water-back explosion, in James Murray's house, which did about $100 damage, and sunny Virginia was represented on the 8th by a similar explosion in Judge S. W. Howerton's residence, at Roanoke, the Judge being severely bruised and scalded.

Most of these explosions (all of those, in fact, of which we could learn the particulars) were due to the freezing of the supply pipes. There being no way in which the pressure in the water-back could relieve itself, it accumulated steadily until it became great enough to blow the stove to pieces. Special care should be taken during cold snaps to see that there is free communication between water-backs and the city mains; for if such free communication exists, the formation of steam in the water-back will do no harm, and the pressure, which might otherwise be disastrous, will easily relieve itself by forcing some of the water back into the mains.

"Fin de Siecle Science."

Under this heading the New York *Sun* of March 14th discusses the exhibition that was given, on the 13th ultimo, in the galleries of the American Fine Arts Society, of New York city, to show the progress science has made within the past year or so.

"It was the second show of the sort," we are told. "The separate booths were presided over by the respective experts in the different branches which they represented, and President John Krow Rees exercised a sort of general supervision. Cards had been sent out to all the academy's friends, and the rooms were crowded.

"The exhibits were strikingly arranged. The corner of the large room in which Dr. Carlton C. Curtis had his botany 'booth' was especially effective. A long obtuse-angled table held a number of microscopes, interspersed with potted palms and hanging electric lights. On the walls behind were stuck up sheets from herbariums. Nearly all of these were studies of undescribed and little known species. Some of the species were brand new, and many of the visitors had their first chance to see the new kinds of North American leguminosæ and saxifragaceæ, and the new Japanese characeæ, with microscopic preparations of their oöspores.

"Some of the most interesting exhibits were in the photographic department. Many pictures made by the recently contrived processes of color photography decorated the walls. There were prints of Turkish rugs, of book bindings, and of paintings, in which the coloring was exactly reproduced. The negatives are made on specially prepared plates corresponding to the three primal colors, red, yellow, and blue. When the red plate is exposed a screen is placed before a camera to shut out the green and yellow constituents, and the same process is observed with the other two. In making the reproduction an imprint is taken mechanically from the red plate with red ink, and the blue print and yellow print are superposed in the same way. The result is a copy of the original in all its colors and shades.

"The same principle was used in the construction of an exhibit called a photochromoscope, which is soon to be placed on the market, together with a camera for making the triplicate negatives. The photochromoscope is somewhat like a stereoscope, except that the views appear in their natural colors. A box of mixed candies which was shown last night was startlingly realistic. A still further application was shown in an adjoining room in the shape of colored stereopticon views which were almost perfection. A man wearing a blue shirt and a red moustache and some views of the Palisades and the surrounding woodland in gorgeous autumn hues were especially satisfactory.

"Dr. T. M. Cheesman's bacteriology booth was brought clear up to date by a specimen of diphtheria anti-toxin and the corresponding toxin. There were also bacteria of every sort in abundance, and with names in inverse proportion to their sizes. One of these, the bacillius prodigiosus, was the true cause, so the scientists say, of the miracle of the bloody host. The bacillus, they assert, grew upon the wafer or altar bread after its exposure in the church during the consecration of the host.

"L. P. Gratacap of the mineralogy booth turned up with six brand new varieties. In the anatomical and physiological departments there any number of things in bottles. Among examples of up-to-date taxidermy in the zoölogical division was the late lamented Chiko, formerly of Central Park, who died last year and was mounted in January by Z. Rowley of the American Museum of Natural History. Chiko looked as natural as he ever did in his cage, and next to him was another chimpanzee, showing the better grade of commercial work of ten years ago, for purposes of comparison.

"In the electrical department the process of electrolysis, as employed in making disinfectants out of sea water, was shown in operation. The disinfectant, made on the spot, was sprayed upon a glass slide fairly alive with microbes while the observer looked through a microscope and saw them stop short and shrivel up almost as quickly as if they had been suddenly frozen in.

"The new illuminating gas which is made from calcium carbide was also made on the spot. The process is a very simple one. The carbide is a by-product of certain electrical furnace processes. It is put in a jar, water is poured on it, and the gas is evolved. The cost is said to be ten cents a thousand cubic feet, and a burner consuming a foot an hour, and giving a flame of the usual size, makes a light three times as bright as an ordinary incandescent electric light.

"When the visitor was tired of looking at these things, and the exhibits in the departments devoted to geology, palæontology, mechanics, psychology, and astronomy, he could go and have his voice photographed in the department of physics. The contrivance for accomplishing this feat was exhibited by Dr. Floyd S. Mackey and Dr. W. Hallock. The victim was instructed to sing into an orifice and attune his cry to a fork which sounded the bass C. Inside the contrivance were resonance tubes set for C and for seven overtunes, or harmonics. Behind each of these was a drum, which vibrated for the tone of a harmonic. These connected by rubber tubes with little jets of gas, so that the latter jumped up and down when the drums vibrated. The lights were photographed by a camera which was swung quickly past them, the resulting records being in the form of wavy lines. Each line represented the tone, or an overtone, and showed their relative presence in the voice tested. The stronger the tone was, the wavier the line. The object of the apparatus is to ascertain what proportion of overtones is desirable in a singing voice. Specialists have never been able to tell a throat belonging to a good singer from any other. Several famous singers have had their voices photographed with the new apparatus, and these will be compared with ordinary and unmusical voices. The difference in voices once determined in this way, the different throat structures may be better studied, and we may yet have specialists advertising to furnish ambitious young women with first-class operatic voices by simple alterations in the structure of their throats."

A Wonderful Mushroom Opera House.

For some months past the people of Colfax have heard wild rumors of the intention of the band to erect an opera house some time in the near future, but no three persons outside of that organization suspected until yesterday morning that there had been any definite shape to their many plans; but now the institution is an astonishing reality and one of which the city will be proud for many years to come.

On Wednesday night there seemed to be something wrong with the electric light plant, and the streets were in total darkness. Inquiries were answered with the intelligence that the engine was out of order and the plant could not be operated. The people were satisfied with this reply and but little comment was made. Now, it seems to have been part of a plot on the part of the band to hide their scheme. Street loungers had noticed for several days the beginning and progress upon the work of putting in the foundation of the new building on the Codd and Stravens lots north of the First National Bank, and in the last few days immense piles of brick and lime had been hauled to the street in front of the place, but it caused little suspicion.

Soon after it got thoroughly dark Wednesday night a force of about seventy-five men were brought in from Spokane on a freight train, and, unloading near the Main street bridge, armed with hods and trowels, marched to the place and silently began the work of laying the brick upon the new building. As that side of the street was obstructed and the night a dark one no one passed near the building and the ruse was not discovered. Stealthily the men passed up and down and along the walls and rapidly they sprang upward through the night. By daylight the outside walls were finished, and before any one was astir on the streets yesterday morning the scaffolding was taken down, and there stood in magnificent eloquence the proudest opera house in the Northwest.

Men, women, and children thronged down the street dumb with astonishment and admiration. It seemed that nothing short of magic could have erected such a structure without causing suspicion of what was going on.

Just before daylight the masons finished their work and silently departed, while their places were filled with as many carpenters, plumbers, decorators, painters, etc., and all day the work went noiselessly on inside the walls. The heavily curtained windows and closely fastened doors were besieged all day by anxious people, but revealed nothing. At 10 o'clock a bill poster, armed with a paste brush, came down the street, and stopping in front of the building, put up bills announcing that the Colfax Dramatic Company would star their old-time favorites, George J. Joyce, W. J. Bryant, and C. E. Irwin, in the drama "Hick'ry Farm," at the Colfax Opera House. Last night, when the announcement was recognized by the anxious and excited crowd, a long cheer of approval went up. The good news spread like wildfire, and when, at 7.30 last night, the building was thrown open, the streets were crowded from the Colfax hotel to the court house.

Marshal Mackay had to call out his entire force of one other man besides himself, to maintain order. The jam at the box office was almost suffocating, but the crowd was served and seated in the beautiful and capacious auditorium by 8.30, and the curtain rose amid thundering applause, which was repeated at intervals all through the evening. When the curtain had fallen on the last act, and the villain was finally and securely dead, the audience would not be pacified until the act had been thrice repeated for their benefit. — *Spokane Spokesman.*

A Kitchen Boiler Explosion in Scotland.

The following extract from the Glasgow *Weekly Mail* of February 16th is of interest in connection with the kitchen-boiler question that has agitated England and Scotland for the past year or two.

"An explosion of a kitchen boiler, attended with great destruction of property, and with the serious injury of two domestic servants, occurred about five o'clock on Thursday afternoon, in the house of Mr. Wm. Fleming Russell, coal merchant, at 1 Montgomerie Street, in North Kelvinside. From the information in the possession of the Maryhill police, it appears that the cold and hot water pipes throughout the house, which consists of ground floor and sunk flat, having been frozen for a week past, a plumber was engaged on Wednesday putting two new ribs into the kitchen range, and he offered the advice that a small fire should be lit in the grate. Without doubting the wisdom of this counsel the cook put on a fire as advised, and kept on increasing it until Thursday, when she had it roaring. Shortly before five o'clock in the afternoon the noise of escaping steam was heard, and before anything could be done in the way of prevention an explosion took place. The noise created was terrific, and the havoc done in a moment almost beyond description. The boiler itself was blown through the kitchen roof, tearing a large hole in the floor of the drawing-room, which is situated directly overhead, and, still ascending, struck the ceiling of this apartment, and afterwards fell back, otherwise wrecking the room and its contents. In addition to this, by the force of the concussion, a partition wall in the kitchen was laid low, no fewer than eleven windows were blown out, and the vestibule and main door of the house situated on the ground flat, and several yards distant from the kitchen, were burst out towards the street. The cook (Margaret Young) and the nurse (Esther Longbottom), who were in the kitchen at the time, miraculously escaped with no more than a severe shock to the nervous system, and after having been examined by Dr. Whyte, assistant to Dr. Hay, casualty surgeon, were sent to the Western Infirmary in a cab. The fire brigade were called out, but their services were not required.

"Detective John M'Phail of the Maryhill division, who has been investigating the affair, informed the representative of the *Mail* that the boiler which burst was situated above the kitchen range, and was not the ordinary hot-water boiler, which lay at the back of the range. This upper boiler had a flat end on which it rested, and another end in shape like the rounded bottom of a common lemonade bottle. They hadn't discovered yet the plumber who gave the cook the rather peculiar advice in the circumstances to put on a fire in the range with frozen pipes under treatment, but at any rate the girl acted on the advice on Wednesday, and the fire had been kept on until it was roaring on Thursday. Of course the gas and the steam accumulated in the circulating boiler above the range, and, the pipes being frozen, there was no escapement for the steam, with the consequence that the inevitable burst occurred. The boiler itself was wrenched from the flat end on which it sat and went smashing through the ceiling, tore through the floor of the drawing-room and crashed against the ceiling of that room, again cutting a hole in it, and fell back amongst the furniture. As to the appearance of that interior, after the disaster, the furniture of the drawing-room was left a perfect wreck. Sofas, tables, and chairs were hurled and heaped one on top of the other, and to make confusion worse confounded the place was strewn with bricks and lime, and there was a gaping void in the floor several feet in diameter. Half of the partition wall where the boiler was situated was blown down, and bricks and lime littered the kitchen in every direction. As showing the tremendous force of the concussion, Mr. M'Phail mentioned that eleven of the windows had been blown right into the street, and the vestibule door, although a strong one, and at the other end of the house, distant several yards from the seat of the explosion, and on the upper flat, was carried clean off its hinges, and carried into Montgomerie Street. Even a door round the angles of the lobby in the sunk flat had its panels smashed to pieces. In the interior of the kitchen itself to move about one had to climb over piles of brick, lime, and furniture. The residence throughout, it is scarcely necessary to add, is rendered uninhabitable, and on Thursday night a constable was left in charge. It is instructive to note that the lady of the house was apprehensive of danger before the accident. At least twenty minutes prior to the explosion she went down to the kitchen and warned the domestics of the fear she entertained. They paid no heed, however, and she actually took the children to an upper flat and kept them there at the other end of the house. Had they been in the low flat it is fearful to speculate what the consequences might have been. When the explosion took place the girl Longbottom was standing opposite the scullery door, and she was carried off her feet and blown into the scullery. The other girl was near the table at the time, and she was hurled across the apartment and against the opposite wall. She is unable to speak, but the doctors are of the opinion that apart from severe shock the girls have sustained no injuries. Having been so near the seat of the explosion it is really astonishing how either of them escaped with their lives. The report was so great that it was heard at the Great Western Road, almost a quarter of a mile away."

The oldest known fire engine for pumping water is probably the one mentioned in the "Spiritalia" of Hero, about 150 B. C. This engine, it is said, was contrived with two single-acting pumps with a single beam pivoted between the two for working the plungers. The streams of water united in a single discharge pipe and passed up a trough having an air chamber, and out of a nozzle which might be turned in any direction as desired. Fire engines appear also to have been used extensively by the early Romans, who furthermore organized regular fire brigades.

In the early part of the sixteenth century a fire engine known as a "water syringe" was introduced, which, in a measure, resembled the modern form of fire engines. This was mounted on wheels and the water pumped by levers. This form of engine was very generally used in Germany. In England, about the same time, large brass syringes were used. These held several quarts of water and were operated by three men, two of them holding the syringe at each side with one hand and directing the nozzle with the other, while the third operated the plunger. It was necessary, after having discharged the water from the syringe, to refill it from a well or cistern near the fire or from buckets. The syringes were later fitted to portable tanks of water.

The first successful fire engine was probably the Newsham engine, and this was the pioneer of manually operated fire engines. The pumps in these engines were built on many different designs, but in most cases they were operated by levers. Fire engines similar in form to the Newsham engine were in use up to the year 1850. — *Public Opinion* (London).

The Locomotive.

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The Woburn Explosion.

An already large list of Monday morning explosions has been further increased by a very destructive one to life, limb, and property, which happened at the tannery of Mr. F. A. Loring (operated by J. M. Jones & Co.), at Woburn Highlands, Mass., on April

FIG. 1. — GENERAL VIEW OF THE RUINS.

1st. Five lives were lost by it, and serious injuries were inflicted upon about a dozen other persons. The aggregate property loss was probably $20,000.

The steam plant consisted of a battery of four horizontal tubular boilers, the exploded one being known as "No. 4." During the previous day Nos. 3 and 4 had been put out of service for the purpose of having them inspected, steam being meanwhile maintained on Nos. 1 and 2, which had been inspected the week previous. Under these circumstances the stop-valves on the boilers Nos. 3 and 4 were of course closed; and this was the state of affairs when we inspected these two boilers, as already described, on March 31st. The report of that inspection was promptly made, and it states that there was some accumulation of scale upon the heating surfaces — nothing serious, however — and recommends that this scale be removed. It was also noted that there was some local corrosion of the sheets, though not enough to make the boiler dangerous at the pressure under which it is operated, — 80 pounds. The report certifies that the safety-valves, steam gauges, and other safety appliances, were examined and tested, and the boilers were pronounced safe for 80 pounds of steam under the conditions under which they were operated.

At the time our inspectors made their examinations, — that is, on March 15th, March 24th, and March 31st, — they found Michael Lally acting as head fireman in charge of the boilers, and thought him a very competent and experienced man. Indeed, so far as this company is informed, and so far as we could learn by our own investigations, his character, ability, and fidelity are unquestioned. It is said that he had three years' experience as a fireman in the U. S. Navy, with additional experience at other steam plants. If this be true we think there can be no doubt that he could have passed a creditable examination, and obtained license papers as an engineer, or head fireman, had it been required by law.

After boilers Nos. 3 and 4 were examined as described, it devolved upon the management to prepare them for service again by properly replacing the man-hole and hand-hole plates, filling the boilers with water, and starting the fires. When steam was gotten up to the same pressure, in Nos. 3 and 4, that existed in the other boilers (carefully noting the behavior of the steam and water gauges and safety-valves during this time), then, *and not till then*, should the stop-valves have been carefully opened, and the connections made with the remaining boilers of the battery. This operation of getting up steam after boilers have been out of service, is one which requires the exercise of the greatest skill and judgment; this is especially true when part of the boilers of a battery have steam upon them at the time. Our company does not contemplate that this important duty shall be performed by other than the most competent and experienced men.

The judicial inquiry made since the explosion has established the fact that on this particular night of March 31st, the duty of getting up steam, and connecting all the boilers together, devolved upon two men, one of them being a night watchman, who had been a yard laborer until some two weeks before, and who was utterly ignorant of the duty to be performed, and the other a night fireman, also without adequate experience, and perhaps without experience at all, who had been hired two nights before. These men were not questioned as to their knowledge of the duty to be performed (as it was not known by our company that they were to be entrusted with it), and they claim that they received no special directions from the managers or superintendent of the works. This inquiry also established the facts that from about ten o'clock P. M. (the time of starting fires upon boilers Nos. 3 and 4), until the explosion of No. 4 boiler, just before 7 A. M., when the engine was started and the whistle blown, the men had been in trouble, and had sought the assistance of acquaintances in the neighborhood; that they had hauled fires and started them again, that they had had trouble getting water into No. 4, that the watchman at about 3 A. M. had called the superintendent (who did not then respond), that steam was heard to blow off violently at 5.15 A. M., and that before the superintendent was called the fires were burning and the water had fallen considerably below the lower gauge in No. 4 boiler. Inasmuch as the fusible plug was known to be intact the day before, and was found partly fused after the explosion, the inference seems conclusive that this plug was fused at that time; and probably no one conversant with steam boilers who heard or read the testimony in this case was surprised that an explosion occurred. Whatever there is of wonder, it is that the whole battery was not blown up.

FIG. 2. — GENERAL VIEW OF THE RUINS.

Owing to this plant having changed ownership several times during the past twenty years, it has been difficult to determine positively the age of boilers Nos. 3 and 4. It is reported that they were built by Messrs. Wm. Allen & Sons, boiler-makers, of Worcester, Mass. They were constructed of steel plates, $\frac{5}{16}''$ thick, and consisted of four rings of plates, double riveted along the horizontal seams. They were supported by three cast-iron lugs on each side. The heads were of steel, $\frac{3}{8}''$ thick, well stayed. They were 60″ in diameter, and 16 feet long, and they contained 54 four-inch tubes. According to the United States tables of pressures, such boilers might have been allowed a maximum steam pressure of 124.99 pounds, when new. Taking into consideration their age, condition, and service, this company allowed 80 pounds, at which pressure it is admitted by the United States inspectors, and by the State steam-boiler inspectors, as well as by various expert engineers, that they were absolutely safe, when properly handled. No boiler, however good and strong, is safe in inexperienced hands!

Judging from the way in which the pieces were projected, the initial rupture of No. 4 boiler occurred near the juncture of the girth and horizontal seam on the left-hand side of the fourth ring of shell plates; the break then following the line of greatest weakness, — *i. e.*, running between the rivet holes of the horizontal seam. The sheet was stripped off from the other part of the shell, and also from the back heads; it was straightened out, and it probably struck the chimney or some part of the building a heavy blow, as it was deflected to the left, and when recovered was some three hundred feet from its starting point. Had its course not been thus modified, it would probably have done even greater damage to the buildings to the right of the boiler-house, perhaps with greater fatality to the workmen who were in those buildings, preparing to commence their day's work. The forward part of this boiler, with the front head and three courses of the shell, was driven endwise about 35 feet into the second floor of the tannery, demolishing everything in its path. This portion of the boiler, so far as can be determined, was the chief cause of the loss of life and injury to person that resulted.

The 54 four-inch tubes belonging to this boiler were hurled to the rear in a right and left direction, for some 400 or 500 feet around. No. 3 boiler, adjacent, was turned end for end and upside down, and had apparently been thrown high in the air. No. 2 had its connections all stripped off and its setting demolished, while No. 1, except for the shattering of the brick setting and the carrying away of the steam and water connections, was not seriously injured. The destruction of the boiler, buildings, chimney, pipe connections, and fittings, was so complete as to leave no doubt in the minds of any one conversant with such matters that the pressure that exploded this boiler must have been a very considerable one. Self-preservation is said to be the first law of nature, and as boiler explosions are commonly the result of negligence on somebody's part, those who have a knowledge of the affair, and survive, are generally more inclined to add to the mystery than to attempt to clear it up by telling, to their disadvantage, their own part in it. Hence, in such an investigation we must depend more upon a careful examination of the remaining parts of a boiler, its attachments and fittings, and the mute testimony they afford, than upon admissions to be obtained from the survivors. Just what occurred in that boiler-house on the night preceding the explosion, or the order in which it occurred, will possibly never be known. The stories of the survivors (the night watchman and night fireman), are very conflicting, and are not reconcilable with what has been made public through other channels; but fortunately we know they were seeking aid wherever they thought they could get it, and it may be assumed that they naturally would not let the superintendent know of their failure to do what was expected of them, so long as it could be concealed.

An examination of all the available information shows that No. 4 boiler, at the time of explosion, was in good condition for a pressure considerably in excess of 80 pounds. Therefore there are the best of seasons for assuming, inasmuch as it did explode, that something out of the ordinary occurred in its management, by which its strength was impaired. This would be the natural result of the distortion of the horizontal lap seam, if it were overheated while the water is admitted to have been low (*i. e.*, at the time the fusible plug was partly melted); and it is probable that the bursting pressure of this boiler was considerably reduced, at the weakest part, by an injury of this sort. It appears that the partial melting of the fusible plug has not attracted the attention, in some quarters, that it deserves; nor has the true significance of what occurred, during the night, been appreciated by those of limited experience, who reason more from a theoretical standpoint than from a practical knowledge of such matters. It is within the observation of those who have had much to do with fusible plugs, that even when they are refilled periodically, they fuse completely, or partially, with a greater or less exposure. It is not contended by this company that the water was so extremely low in No. 4 boiler as to bulge that part of the back head in which the fusible plug was

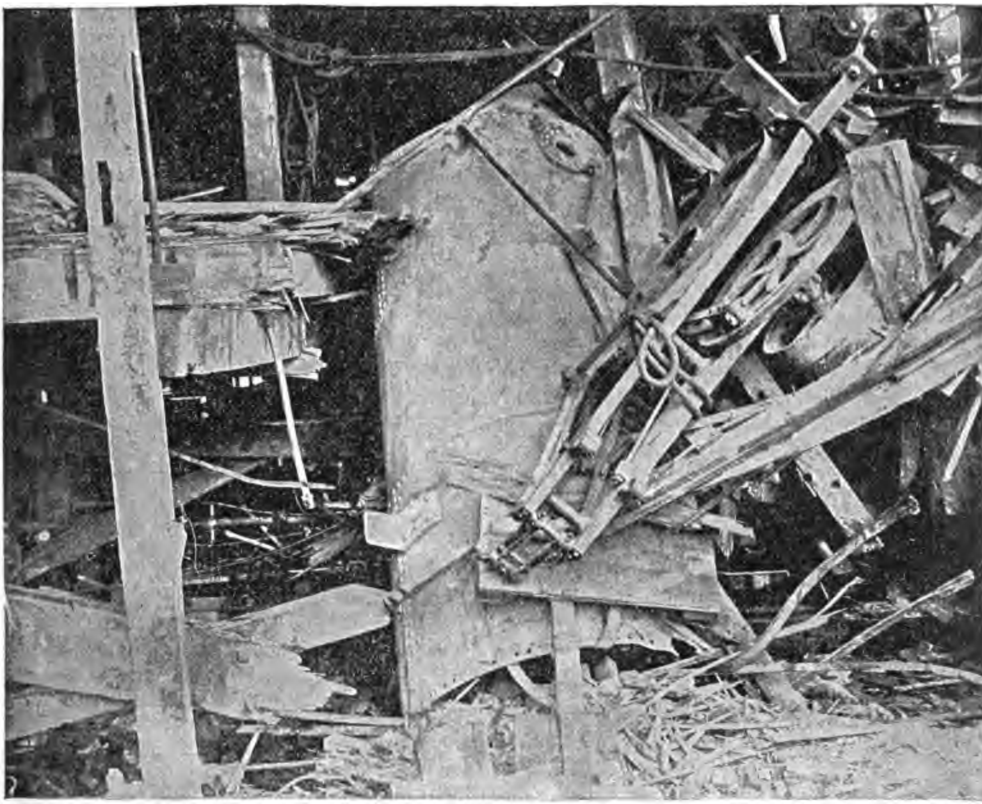

Fig. 3. — Some Details of the Wreckage.

placed; it is evident that the heat fell short of that. To cause such a bulge the water would have had to be even lower than it is claimed to have been, judging from the appearance of the plug and the shell of the boiler. It is evident, though, that there are *degrees* of overheating, and an overheating sufficient to distort and greatly injure a lap-riveted seam in the fire might not appreciably injure the plates in the head or the sheets. Seams are always the first to suffer, and they suffer the worst because a double thickness of plate at the lap throws the boiler out of the cylindrical form at this point, and the first effect of the stress due to overheating under great pressure (such as is assumed to have occurred), when combined with the effort of that part of the shell to assume a circular form, is to either rupture or distress the joint, according to circumstances. If this assumption be true, it certainly was more than probable, under the circumstances, that the strength of the boiler under consideration would have been so reduced by the injury it suffered, that it would explode disastrously at a much lower over-pressure than would its mate, No. 3, or than it would have required, itself, previous to the injury.

Our illustrations are from photographs taken shortly after the explosion.

As some criticism has been elicited by the fact that the boiler at Woburn exploded the day after it was inspected, it is proper to call attention to the foregoing article as showing that inspection is no guaranty against carelessness and ignorance of the proper management of steam boilers. A boiler in perfect condition may explode in two hours after inspection, if put under the management of an ignorant, incompetent man. The Hartford Steam Boiler Inspection and Insurance Company carried 57,000 boilers through the year 1894, and only 9 of them exploded,—that is, only one boiler in 6,333, or less than $\frac{1}{63}$ of one per cent. of those insured. The company employed during the same year 140 inspectors, all of whom are constantly engaged in this particular department of the company's business, and all of whom are capable men, with wide experience in mechanical and steam engineering. This department alone of the Company's business cost, during the year 1894, nearly $300,000; and it is to its efficiency that the low loss-ratio is to be attributed. Those insured with us reap the benefit of the advice of this corps of practical experienced men, and know it to be valuable. We were somewhat amused, recently, at receiving a copy of a trade paper published in Boston, in which was an article entitled, "*Does Inspection Inspect?*" The article was mainly devoted to a criticism of the Hartford Steam Boiler Inspection and Insurance Company and its methods. Cases of exploded boilers were cited, which were never inspected nor insured by us. There were tears and blood in the eye of the person who wrote the article. His disturbed equilibrium and venom pervaded every line. And why? An agent of this trade sheet called at our office several times to secure an advertisement from us, a short time before the Woburn explosion, and he didn't get it.—*Hinc illæ lacrimæ.*

Boiler Explosions.

March, 1895.

(76.)—A traction-engine boiler exploded, on March 1st, at Jacksonville, Ill. John Seymour and Howard Seymour were terribly injured.

(77.)—A boiler exploded, on March 2d, at Gibsonville, twelve miles east of Adelphi, Ohio. Three men, named Snyder, Brown, and McBride, were blown to pieces, and another man, named Smith, received a fracture of the skull, from which he died. John McCrooms and —— Augsberg were also horribly crushed, but not killed. The building in which the boiler stood was blown to atoms. This is the fifth boiler explosion that has occurred within a radius of twelve miles during one year. The five explosions referred to (one of which happened on February 26th of this year) resulted in a loss of twelve lives.

(78.)—A locomotive boiler, on the Central Railroad of Georgia, exploded, on March 2d, near Weems, Ala. Engineer F. A. McGuire and Fireman William Reeves were instantly killed. The locomotive and three cars were totally demolished, nothing being left of the locomotive itself but the wheels.

(79.) — A safety boiler exploded at the Laurel Hill colliery, Hazleton, Pa., on March 3d. John Sherman was badly bruised about the face and head, and one of his legs was broken.

(80.) — A boiler exploded, on March 6th, in Runkle, Rowley & Co.'s mill, at Runkle's station, near Piedmont, S. D. William E. Warren and Andrew Dillehay, Thomas Collins, Robert Repass, and Amos Wright were painfully injured. The boiler was literally blown to atoms, and the building was almost completely wrecked. Pieces of the machinery were thrown fully three hundred feet. The property loss is variously estimated at from $2,000 to $5,000.

Fig. 4. — A Section of the Exploded Boiler.

(81.) — A boiler exploded at the B. F. Goodrich company's rubber works, at Akron, Ohio, on March 7th. John Vance, a machinist, was struck on the head by a flying fragment, and died in about ten minutes. John Somerville, who was working with him, was severely burned and scalded, and several other employes received lesser injuries from the falling walls. A number of surrounding buildings were injured by the explosion. We have seen no estimate of the total damage done.

(82.) — On March 7th, a boiler exploded in A. M. Kinney's mill, five miles east of Hillsdale, Mich. Mr. Kinney was killed, and his son and another workman received painful burns. The mill was torn to atoms, and large trees, eighty or ninety feet away, were twisted and splintered by the flying pieces of the boiler.

(83.) — A portion of the sectional heating boiler in the schoolhouse at Menekaune, Wis., burst on March 8th. Nobody was injured, and the scholars had a day's vacation.

(84.) — James McGrew and Emmet Ford were badly injured by a boiler explosion at Winchester, Ohio, on March 8th. McGrew was fearfully scalded, so that he died during the evening. Ford was badly cut and bruised by flying debris, but his injuries are not fatal. The building in which the boiler stood was demolished, and the stack was also blown down.

(85.) — The locomotive of the Pacific express, leaving Harrisburg for Altoona, Pa., on the Pennsylvania Railroad, at 3.10 A.M. on March 9th, was destroyed by a boiler explosion at Cove Station, near Harrisburg. Fireman John H. Peffly was injured so badly that he died within five minutes. Engineer John A. Funk was severely injured also, but it is thought that he will recover. "We left the Union Station [at Harrisburg] on time," said Mr. Funk, "and ran along at the usual rate of speed. At Marysville I saw that there was plenty of water in the boiler, and shut off the injector from Marysville Tower to Perdix. At Cove Station I looked at the steam gauge and saw that there was a steam pressure of about 175 pounds, and that the water gauge indicated a boiler three-fourths full. The injector was on. I got up and saw that the white light was displayed at the tower, and remember nothing more of what occurred until I heard those about me in the car speaking. I asked Assistant Road Foreman Clemson 'What's the matter?' 'No. 926 has blown up,' he answered. 'Then,' I said, 'she went up with plenty of water in her boiler.'"

(86.) — A boiler used in connection with an illicit still exploded at Bay Side, L. I., on March 12th. The still was operated by a man named Stile, one of whose children was fatally injured. Stile, his wife, and two other children were also seriously injured.

(87.) — On March 13th, a boiler exploded at Pennington & Winckler's cotton gin, at La Crosse, a station on the Atlantic & Danville Railroad, about twenty miles east of Boydton, Va. The engineer and fireman were killed instantly. The explosion shook the earth for six miles around, so that the people of the surrounding country thought an earthquake had occurred.

(88.) — A boiler expoded near Chuckaluck, McMinn County, Tenn., on March 15th. Nobody was killed, but a boy name Carpenter was seriously bruised about the head and face. The machinery of the mill was ruined.

(89.) — A boiler exploded, on March 16th, at the Lawrence Steam Dye Works, Lawrence, Mass. It is said that it was designed for 60 pounds pressure, and that at the time of the explosion it was carrying but 35 pounds. None of the employés were near at the time, and nobody was injured.

(90.) — On March 17th, a boiler exploded at the South Village mill of the Slater Woolen Company, at Webster, Mass. The engine-house and the dry-room, two large one-story brick buildings, were completely demolished. In the dry-room were 200 bales of wool, valued at $1,500, which were ruined. In the engine-house there were two engines, one of them a 200 horse-power Corliss, valued at $5,000, and the other a 150 horse-power Green engine, valued at $3,000. These engines, together with the dynamos used for lighting the plant, were ruined also. It is said that the total damage, including buildings and machinery, will amount to $75,000. The front head of the boiler blew out, and the reaction of the issuing steam and water caused it to start "cross country" like a rocket. In its course it passed endwise through a 10'×12' parlor in one of the neighboring tenement-houses. Rosa Domi, a young girl, was in the room at the time, and how she escaped instant death is beyond comprehension. The entire floor of the room was torn away from under her, and she fell into the basement below. Her fall resulted in numerous bruises, but otherwise she was not injured. As the explosion occurred at noon on Sunday, nobody was injured about the plant itself.

(91.) — Six men were killed and five others seriously wounded, on March 19th, by the explosion of a boiler at Hall's mill, 33 miles south of Marshall, Tex. The shock of the explosion is said to have been felt at Marshall. We did not learn further particulars.

(92.) — The boiler of an agricultural engine exploded, on March 20th, near Bucyrus, Ohio. John Wirtz (the owner of the boiler) and a hired man were badly injured. The engine was blown into a barn, setting it on fire, and totally destroying both barn and contents.

(93.) — One of the six boilers in S. T. King & Co.'s lumber mill at Kingsville, about four miles from St. John, N. B., exploded on March 20th. Wellington Smith was killed, and Henry Conwell, Fred LeBlanc, Charles McGuire, James Murphy, John Murphy, James Landers, and Matthew Galbraith were more or less severely injured. A lad named Keefe was also slightly injured. The boiler-house was completely wrecked, and the mill itself was considerably injured.

(94.) — A boiler exploded, on March 20th, in the stave factory at Mt. Pleasant, Maury County, Tenn. We have not learned particulars.

(95.) — A boiler exploded, on March 26th, in Amos Hutchins' mill, near Van Wert, Ohio. Blakely Shaw and Fred Hutchins were killed, and Melville Storz, Isaac Bowman, and Neil Fassett were badly injured. The mill took fire, and was destroyed.

(96.) — On March 27th, a boiler exploded in Johnson's mill, on Sugar Creek, about five miles from Shelbyville, Tenn. Elijah Cunningham was killed, and Humphrey Cunningham, his brother, was blown a considerable distance and severely injured. Several other men received lesser injuries. The engine-house was completely demolished, and several small structures near it were likewise destroyed.

(97.) — A boiler exploded, on March 27th, in the Langston saw-mill, at Apple Valley, near Harmony Grove, Ga. William Goode, John Langston, and a negro woman were killed. Edward Churchwell, F. M. Langston, and ——— Holbrook were severely injured. The explosion was heard five miles away. The boiler was hurled 150 yards up a hill, mowing down a number of trees in its passage.

(98.) — On March 28th, a boiler exploded in the basement of Gerdes' Hotel, Cincinnati, Ohio. The explosion was slight. Nobody was injured, and the damage was small.

(99.) — The boiler in Williams' saw-mill, in Dunklin County, near Dexter, Mo., exploded on March 28th, killing John Waynick, the fireman, and injuring Elijah Warner, William Snipes, John Foley, John Gowan, and Charles Warner. The machinery was literally torn to pieces. A section of the boiler was blown through two walls of a gin-house, and into a field seventy-five yards away. Fragments of the boiler-house and pieces of machinery were thrown 2,000 yards from the site of the mill.

(100.) — On March 29th, a boiler exploded on a steamboat used by a dredging party near Beardstown, Ill. William May was instantly killed, and Alonzo Bollinger was seriously injured.

(101.) — The boiler in D. J. Ingersoll's mill at East Leon, near Randolph, N. Y., exploded on March 29th. D. J. Ingersoll and Denziel Ingersoll were instantly killed. Mrs. D. J. Ingersoll and Davillo Hunt were badly injured. The mill was demolished.

Inspectors' Report.

MARCH, 1895.

During this month our inspectors made 8,479 inspection trips, visited 18,136 boilers, inspected 6,284 both internally and externally, and subjected 569 to hydrostatic pressure. The whole number of defects reported reached 12,154, of which 1,396 were considered dangerous; 85 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	897	45
Cases of incrustation and scale,	1,987	65
Cases of internal grooving,	119	9
Cases of internal corrosion,	695	55
Cases of external corrosion,	859	72
Broken and loose braces and stays,	223	82
Settings defective,	318	44
Furnaces out of shape,	459	26
Fractured plates,	360	71
Burned plates,	287	33
Blistered plates,	206	15
Cases of defective riveting,	1,504	72
Defective heads,	102	33
Serious leakage around tube ends,	2,018	450
Serious leakage at seams,	531	52
Defective water-gauges,	452	80
Defective blow-offs,	199	64
Cases of deficiency of water,	17	11
Safety-valves overloaded,	93	26
Safety-valves defective in construction,	148	35
Pressure-gauges defective,	570	36
Boilers without pressure-gauges,	20	20
Unclassified defects,	90	0
Total,	12,154	1,396

THE ratio of the specific heats of the new element, argon, is said to be 1.66.

Our Country's Progress, as Seen by a Foreigner.

The English statistician, Michael G. Mulhall, publishes, in the June number of the *North American Review*, an article on "The Power and Wealth of the United States." Mr. Mulhall's conclusion is that:

"If we take a survey of mankind in ancient or modern times as regards the physical, mechanical, and intellectual force of nations, we find nothing to compare with the United States in this present year of 1895, and that the United States possesses by far the greatest productive power in the world."

Mr. Mulhall shows that the absolute effective force of the American people is now more than three times what it was in 1860, and that the United States possesses almost as much energy as Great Britain, Germany, and France collectively, and that the ratio falling to each American is more than what two Englishmen or Germans have at their disposal. He points out, by a careful comparison between the conditions in these different countries, that an ordinary farm hand in the United States raises as much grain as three in England, four in France, five in Germany, or six in Austria. One man in America can produce as much flour as will feed 250, whereas in Europe one man feeds only thirty persons.

Mr. Mulhall calls special attention to the fact that the intellectual power of the great republic is in harmony with the industrial and mechanical, eighty-seven per cent. of the total population over ten years of age being able to read and write.

"It may be fearlessly asserted," he says, "that in the history of the human race no nation ever before possessed 41,000,000 instructed citizens."

The post-office returns are appealed to by Mr. Mulhall in support of this part of his statement, these showing that, in the number of letters per inhabitant yearly, the United States are much ahead of all other nations.

According to the figures of Mr. Mulhall the average annual increment of the United States from 1821 to 1890 was nine hundred and one millions of dollars, and he adds that "the new wealth added during a single generation — that is, in the period of thirty years between 1860 and 1890 — was no less than forty-nine milliards of dollars, which is one milliard more than the total wealth of Great Britain."

Classifying the whole wealth of the Union under the two heads, urban and rural, Mr. Mulhall finds that rural or agricultural wealth has only quadrupled in forty years, while urban wealth has multiplied sixteen-fold. Before 1860 the accumulation of wealth for each rural worker was greater than that corresponding to persons of the urban classes; but the farming interest suffered severely by reason of the civil war, and since then the accumulation of wealth among urban workers has been greatly more than that among rural workers, a fact which Mr. Mulhall thinks explains the influx of population into towns and cities.

In a series of figures Mr. Mulhall shows that the "rise in wealth and increase in wages came almost hand in hand." In dealing with the development of farm values, he makes the following statement:

"If the United States had no urban population or industries whatever, the advance of agricultural interests would be enough to claim the admiration of mankind, for it has no parallel in history."—*Scientific American.*

A fitting burst, recently, on the main steam pipe in the Broadway cable power house, at Sixth avenue and Fiftieth street, New York. The pipe was carrying steam at a pressure of 100 pounds to the square inch. The main stop-valve was closed as quickly as possible, and repairs were begun at once: too soon, in fact; for one of the workmen was scalded by hot water that spurted from the broken pipe.

The Locomotive.

HARTFORD, MAY 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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THE twentieth annual *Report* of the Märkischer Verein zur Prüfung und Ueberwachung von Dampfkesseln, of Frankfurt, Germany, is at hand.

MESSRS. John Wiley & Sons, of 53 East Tenth street, New York, have kindly sent us a copy of Mr. William Kent's *Mechanical Engineer's Pocket-Book.* We confess that when we examined this work we had no great hope that it would prove to be of especial importance. We did not question the ability of the author, nor the judgment of the publishers; for we have the greatest respect both for Mr. Kent and for Messrs. Wiley & Sons. The field that the book covers simply seemed to be exhausted, and we did not think it probable that a new work could be written which would have distinct advantages over those of the same sort that were in existence. In this we were pleasantly mistaken, for Mr. Kent's book proves to be a valuable addition to the literature of mechanical engineering. It contains 1,070 pages, and covers nearly everything that a mechanical engineer wants to know. In most cases, too, the treatment is very clear. A particularly satisfactory feature is the large number of references to the original papers and books from which the rules and other information are taken. We heartily commend Mr. Kent's *Pocket-Book* to all mechanical engineers.

Effects of Temperature on the Strength of Wrought-Iron.

The pioneers of mechanical engineering, men who had never seen a tensile test made in the whole of their experience, had very little doubt but that iron and steel were less reliable in winter than in summer. As is frequently the case, however, this view was not confirmed by the earlier of the investigations directed towards this point. The first experiments on the subject were, perhaps, those of Sir William Fairbairn, but they were directed mainly to ascertaining the strength of iron at the temperatures at which it is likely to be exposed in boilers, rather than at temperatures below freezing. Still, his experiments, so far as they went, did not indicate a loss of strength, and Knut Styffe, who investigated the matter with much care, confirmed this, and also concluded that the extensibility did not suffer either. Other experimenters, however, got somewhat discordant results, some finding the strength and extensibility both to be increased at low temperatures, while in other cases a slight decrease has been noted in the percentage elongation; others, again, have noted absolutely no difference in the behavior of the metal under test while the temperature ranged from freezing to boiling point. It has long been known that rail breakages are more frequent in winter than in summer, and the same is also true of car axles, but it has been pointed out that in those countries in which this phenomenon is most marked, the winters are very severe, and in consequence the road-bed gets out of shape, and the shocks and concussions to both rails and axles are consequently much more serious in the winter season. This in itself ought to account for a large proportion of the differences in the amounts contributed to the scrap pile by the two seasons respectively. Still, in spite of this, and of the absence of any indication in laboratory tests of a loss of endurance from a reduction of temperature, many practical men still maintained the opinion that iron and steel were really more brittle in winter than in summer.

For certain purposes the rough workshop tests of material give more accurate information as to its value, and with greater ease, than the refined laboratory tests, which require large and expensive plant. By means of the common bending test, Mr. Strohmeyer was enabled to show conclusively the great loss of ductility occasioned by working steel at a blue heat. Tensile tests made afterwards confirmed the result, but its first establishment was due to the common bending test of ductility, which can be carried out by any workman that can wield a hammer. Another favorite workshop test, and one which will probably never be abandoned for certain purposes, is the impact test, invariably used for rails, tires, and axles. For these purposes it has the great advantage of being of the same nature as the shocks and concussions to which failure of these parts is commonly due in practice, and further, it is easy to conduct the tests on full-sized specimens, so that there is less risk of such errors as may arise when experiments are confined to specimen bars, differing possibly in constitution from the finished article. A very extensive series of experiments of this nature, which has been continued over several years, at great cost of time, money, and personal exertion, has been recently completed by Mr. Thomas Andrews of the Wortley Iron Works, Sheffield. These experiments go to show that the indications as to the comparative endurance of iron at a temperature below freezing point and at 212 degrees Fahrenheit, obtained in the ordinary tensile tests, are unreliable, and that there is in fact a decided loss of ductility and of capacity for enduring punishment at the lower temperatures. Mr. Andrews' experiments were made on full-sized railway car axles, made out of "best best" iron at the Wortley works. The axles in question were 7 ft. 3 in. long over all, 5½ in. in diameter at the shoulders, and 4½ in. in diameter at the center, the weight being 423 lb. The metal used had an ultimate strength of about 21½ tons per square inch, with an elongation of between 18 and 20 per cent. on 10 in. The following analyses show the chemical characteristics of the metal. They referred to different samples, but are of the same nominal quality of metal:

Combined Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.	Iron (by Difference).
0.068	0.158	0.007	0.108	0.360	99.299
0.038	0.117	0.019	0.246	0.112	99.468

The first series of experiments were made some ten years ago, and consisted in breaking 42 of the above axles by the impact of a falling weight; some of which were broken at a temperature of 7 deg. to 10 deg. Fahr., while the others were heated to 212 deg. Fahr. The axles to be tested were immersed for 2¾ hours or more in a tank containing either a mixture of snow and salt, or hot water, as the case might be. The temperature of the metal was obtained from a second similar axle drilled near its center with a hole for a thermometer. This axle was placed in the tank and removed from it at the same time as the axle to be tested. This latter was, when ready, supported on a couple of cast-iron blocks secured to a heart-of-oak bedplate, located immediately under the tripod with which the falling tup was manipulated. This latter was of chilled cast iron, and was of rounded form, weighing 1 ton, and was allowed to strike the axle direct without the interposition of any saddle. The clear span of the axle between bearings was 3 ft. 6 in. After each blow the permanent deflection was measured and the axle re-immersed for 15 minutes in the heating or cooling tank, as the case might be. It was then placed in position for a second blow, being turned half round, so that alternate blows were struck on opposite sides. The total of the permanent sets gave, of course, a measure of the work done on the material. Some of the results obtained in this first trial are given below:

Number of Axle.	Height of Fall.	Temperature.	Permanent Deflection caused by Blow Number													Total Permanent Deflection.
			1	2	3	4	5	6	7	8	9	10	11	12	13	
	(Feet.)	(Fahr.)	in	in	in	in	in	in	in	in	in	in	in	in	in	(Inches.)
2	10	7° to 10°	$1\frac{7}{8}$	$2\frac{1}{4}$	2	..	..	..	..	..	..	..	..	..	..	$6\frac{1}{8}$
12	10	7° to 10°	$2\frac{5}{8}$	3	..	..	..	..	..	..	..	..	..	..	..	$5\frac{5}{8}$
4	10	212°	$3\frac{3}{4}$	$2\frac{7}{8}$	$2\frac{1}{8}$	$2\frac{1}{4}$	2	..	..	..	..	..	..	..	..	13
5	10	212°	$3\frac{7}{8}$	3	$2\frac{3}{8}$	$2\frac{1}{8}$	$2\frac{7}{8}$	2	$1\frac{7}{8}$	..	..	..	..	..	..	$18\frac{1}{8}$
7	10	212°	$3\frac{3}{4}$	3	$2\frac{3}{8}$	$2\frac{3}{8}$	2	2	2	2	$1\frac{7}{8}$	$1\frac{7}{8}$	$1\frac{7}{8}$	$1\frac{7}{8}$	$1\frac{7}{8}$	$28\frac{7}{8}$
8	15	7° to 10°	$3\frac{7}{8}$	$4\frac{3}{8}$	..	..	..	..	..	..	..	..	..	..	..	$8\frac{1}{4}$
9	15	7° to 10°	4	$4\frac{1}{4}$	..	..	..	..	..	..	..	..	..	..	..	$8\frac{1}{4}$
10	15	120°	$4\frac{1}{2}$	$4\frac{1}{8}$	$3\frac{1}{2}$	..	..	..	..	..	..	..	..	..	..	$12\frac{1}{8}$
11	15	120°	$4\frac{5}{8}$	$3\frac{7}{8}$	$3\frac{1}{2}$	$3\frac{3}{8}$	3	..	..	..	..	..	..	..	..	$18\frac{3}{8}$

The remaining tests showed results of a practically identical nature, the amount of punishment the axles were capable of standing being much greater at a high temperature than at one below freezing point. There were, however, a few exceptional cases. Thus, axle No. 1, tested with a drop of 6 ft. at a temperature of 7 deg. Fahr., stood 47 blows, the accumulated permanent deflection amounting to no less than 62 in. Axles 3 and 6, tested at the same temperature, with a drop of 10 ft., stood, in the first case, 22 blows, and in the latter 34, the accumulated permanent deflections being respectively $54\frac{3}{8}$ in. and 86 in. When, however, the broken halves of these axles were again tested — one at a temperature of 70 deg. and the other at 100 deg. Fahr.— the warm half showed the greater endurance. The fracture in the cold tests was more crystalline than in the warmer ones. Some peculiar phenomena were observed as regards the rate of cooling of an axle immersed in the freezing mixture. Two and three-quarters hours were required to reduce its temperature to 0 deg. Fahr., and though left for 17 hours in the mixture, no lower temperature was reached, though the temperature of the mixture used was —4 deg. Fahr. This anomaly is not easily comprehensible provided due care was taken in making the readings. Experiments made to determine the difference between the outer and central layers of the axle when immersed in the freezing mixture showed that at no time was this difference great, the maximum divergence noted being 4 deg. Fahr.

The results obtained by this preliminary series of experiments showed that though there were many points requiring further investigation, there was on the whole a decided loss of ductility in the axles tested at the lower temperatures. No explanation of the behavior of the exceptions to this rule has, however, yet been attempted, and it would be interesting to have a chemical analysis of the metal in these cases, with a view to ascertaining whether it differed in any marked degree from the rest of the batch. As is well known, exceedingly small differences in the chemical composition of iron may make enormous differences in its physical properties, thus affording a remarkable instance of the importance of those "next-to-nothings" on which Sir Frederick Bramwell once so pleasantly lectured. The mode of testing adopted seems unimpeachable, the precaution of turning the axles half round after each blow being obviously necessary, as otherwise the resistance of the axles would have been enormously increased, owing to the plastic flow of the metal, after the first blow or two, equalizing the stresses on the cross-section in the same way as when a beam is strained beyond its elastic limit in an ordinary transverse test. If the experimenters, through inadvertence, had omitted to turn axles 1, 3, and 6 round between the blows, the exceptional behavior of these three could easily be accounted for. Such a mistake, however, is practically impossible, as, apart from the security afforded by Mr. Andrews' high reputation as a careful experimenter, the axle itself forms a record of the direction of the last blow, its permanent set showing this in an unmistakable manner.—*Engineering* (London).

Four Hundred Below Zero.

Four hundred and twenty-four degrees Fahrenheit below zero! Just what this means it is almost impossible to imagine, and yet it is one of the temperatures which have been reached and used in laboratory research, and has been made the subject of some highly interesting experiments and explanations by Professor Dewar before the British Royal Institution. Four hundred degrees below zero is not an everyday temperature, nor can it be reached by more everyday means than the expansion of liquid air, which latter Professor Dewar has succeeded in producing in comparatively large quantities.

The tensile strength of iron at 400 degrees below zero, is just twice what it is at 60 degrees above. It will take a strain of sixty instead of thirty tons to the square inch, and equally curious results have come out as to the elongation of metals under these conditions. It was an idea of Faraday that the magnetism in a permanent magnet would be increased at very low temperatures, and experiments with comparatively low temperatures had rather negatived Faraday's suggestion, but Professor Dewar has completely verified the opinion of the famous savant, having shown that a magnet at the extremely low temperature made possible by the liquid air had its power increased by about 50 per cent.

Very low temperature was shown also to have a remarkable effect upon the color of many bodies. For example, the brilliant scarlet of vermillion and mercuric iodide is reduced under its influence to a pale orange, the original color returning with the rise of the temperature. Blues, on the other hand, are unaffected by cold, and the effect is comparatively small upon organic coloring in matters of all tints. — *Cassier's Magazine.*

The Locomotive.

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Water Columns, Gauge Glasses, and Steam Gauges.

In a recent issue of The Locomotive we briefly described the settings of externally fired horizontal tubular boilers, and we shall now review, in a similar manner, the fittings and connections, which are quite as important as the setting.

The water column, which should be provided with three try-cocks and a glass gauge, should be connected by solid-drawn brass tubing, iron pipe size and thread. A

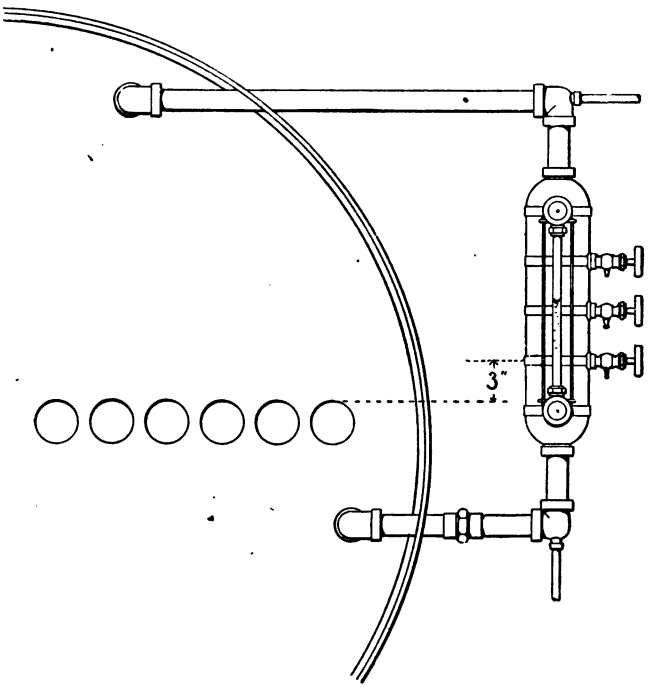

Fig. 1. — Showing How to Connect the Water Column.

ground brass union is placed in the water connection, so that the column can be readily disconnected, and the piping examined and cleaned.

In the cut we show the parts connected up by elbows, in the usual manner. Some engineers prefer to use double tees in place of the elbows, as shown and described in The Locomotive for February, 1895, in order that the pipes may be cleaned by merely removing the plugs from the tees, and running a straight rod through the pipes. Either construction is satisfactory.

The pipes connecting the water column to the boiler should not be less than one inch in diameter, and when the water contains much sediment we prefer them to be an inch and a quarter in diameter. A half-inch or three-quarter inch drain pipe runs from the elbow (or double tee) in the water connection, to the ash pit. This allows the water column to be blown off, so as to prevent the accumulation of sediment in it. For the sake of neatness, a drip pipe should also run to the ash pit from the gauge-cocks.

The water column should be so placed that the lower try-cock is at least three inches above the top of the upper row of tubes, and the water level should be carried, as a usual thing, a little above the second gauge. If these points are attended to, the boiler will not be liable to injury from overheating, for even if the pump or injector should fail entirely, with the water level at the lower gauge-cock, there will still be ample time to draw the fires and put the boiler out of service, before the upper row of tubes is exposed by evaporation.

FIG. 2. — THE CIRCULAR SIPHON.

In connecting steam gauges the chief points to be considered are these: The gauges should be so placed that they are not liable to injury from the heat of the steam, nor from the heat radiated from the boiler front or uptake; and provision should be made for removing the gauge while the boiler is in service, in case it should be desirable to do so, and also for blowing out the piping without disturbing the gauge.

Some engineers, when erecting boilers, attach the steam gauge directly to the uptake, or to that portion of the boiler which forms the front connection. This is a grave mistake, as the heat is almost certain to injure the spring, so that the gauge will give erroneous readings, and will perhaps be entirely ruined. It is far better to attach the gauge in such a manner that air may circulate about it freely and keep it cool. It may also be carried to one side and secured to the brick setting, or it may be secured to the boiler front if a suitable thickness of non-conducting material is interposed to protect it.

In order to prevent injury from the direct contact of hot steam with the spring, some form of siphon should be interposed between the gauge and the boiler, in which water of condensation can collect and serve as a protection. Fig. 2 shows a form of siphon in common use for this purpose. We cannot recommend this form, however; for although it accomplishes its purpose of protecting the spring from direct contact with steam, it cannot be cleaned without disconnecting the gauge. Moreover, a bent pipe of this kind is especially difficult to clean, under any circumstances; for it is impossible to drive a cleaning rod through it. It is also impossible to clear a siphon of this type of water, which is an important consideration when the boiler is to be shut down in cold weather. If the water in it freezes, the spring is very likely to be ruptured.

The form of gauge connection shown in Fig. 3 works well in practice, and is in every way superior to that shown in Fig. 2. It is built up of nipples and fittings, as shown, and the gauge is provided with a stop-cock and a ground union. There is also a small cock at the lowest part of the siphon, for blowing out such sediment as may lodge in the bend. If the boiler is out of service, the water may be removed from the siphon by merely opening the "air cock"; but if it is desired to blow the pipes out while the boiler is in service, the stop-cock in the vertical pipe should be closed first, so that the gauge may not be injured. After the siphon has been blown out, the gauge

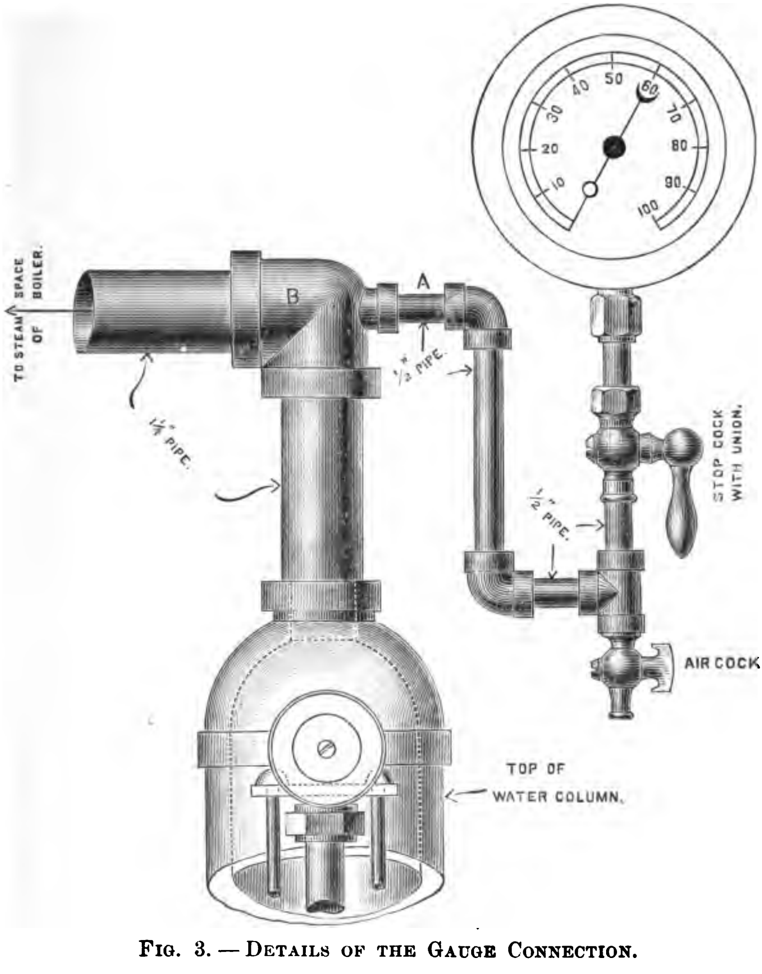

Fig. 3. — Details of the Gauge Connection.

should not be again connected with the boiler until it is judged that a sufficient amount of water of condensation has collected in the siphon to replace that which was blown out.

The form of siphon shown in Fig. 3 is easily blown out, as we have said; and in case it gets plugged so that simple blowing does not clean it effectually enough, it can be readily taken apart, and cleaned by the use of a straight rod of suitable diameter.

The main pipes connecting the water column to the boiler are shown in Fig. 1 with out stop-valves. Some engineers prefer to use such valves, so that in case a gauge glass should break, or a try-cock need cleaning, the water column could be temporarily shut off. We do not entirely favor this plan, because it introduces what we consider to be another source of danger to the boiler.

The valves in question would have our hearty approval, if there were any way to make sure that they should always be open when they ought to be. There is always more or less likelihood of forgetfulness or carelessness on the part of the attendant, and if one or both of the valves should remain closed when the boiler was put into service, either through oversight on the fireman's part or through the meddling of unauthorized persons, the gauge glass would give an erroneous reading, and an accident from low water would very likely follow. Such accidents are not mere possibilities. They frequently occur; and it seems to us unwise to give the fireman unnecessary things to think of and look out for. Of course, the expert would quickly discover the true state of things if the valves were closed, either from the absence of condensation drops trickling down the glass, or from the unvarying position of the apparent water level, or from the failure of the try-cock to work, or in some other way; but, nevertheless, we think it is a bad plan to invite danger unnecessarily. The gauge glass is always provided with valves that can be closed in case the glass breaks, and we consider these to be quite sufficient.

Inspectors' Report.

APRIL, 1895.

During this month our inspectors made 6,923 inspection trips, visited 14,833 boilers, inspected 6,242 both internally and externally, and subjected 621 to hydrostatic pressure. The whole number of defects reported reached 11,859, of which 1,085 were considered dangerous; 83 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	931	33
Cases of incrustation and scale,	2,183	74
Cases of internal grooving,	211	12
Cases of internal corrosion,	730	37
Cases of external corrosion,	828	52
Broken and loose braces and stays,	132	33
Settings defective,	309	33
Furnaces out of shape,	495	16
Fractured plates,	304	49
Burned plates,	315	29
Blistered plates,	314	11
Cases of defective riveting,	1,590	305
Defective heads,	143	16
Serious leakage around tube ends,	1,525	151
Serious leakage at seams,	411	17
Defective water-gauges,	399	70
Defective blow-offs,	210	57
Cases of deficiency of water,	13	4
Safety-valves overloaded,	65	18
Safety-valves defective in construction,	91	26
Pressure-gauges defective.	547	31
Boilers without pressure-gauges,	5	5
Unclassified defects,	108	6
Total,	11,859	1,085

Boiler Explosions.

APRIL, 1895.

(102.) — On April 1st, a boiler exploded at Woburn Highlands, Mass., in F. A. Loring's tannery, which was operated by J. M. Jones & Co. Five lives were lost, and about a dozen persons were injured. The boiler-house was in charge of inexperienced men at the time of the explosion, and it appears that the main stop-valve on the exploded boiler was closed. For some reason the safety-valve did not operate, and steam accumulated until the boiler burst. An illustrated account of this explosion will be found in the May issue of THE LOCOMOTIVE.

(103.) —A boiler in the old G. B. Wiggins mill plant in Saginaw, Mich. (recently purchased by Emery & Simpson), exploded on April 1st, with terrific force. Frank Kelley, a laborer, was instantly killed. John Hartel was cut about the head, and received a severe concussion of the brain, from which he died later in the day. Frank Carpenter was bruised, but soon recovered consciousness, and is now doing well. The mill was almost totally wrecked, and the property loss was about $10,000.

(104.) —A boiler exploded, on April 4th, in James Rainsburg's box factory, on Mill Street, East Lockport, N. Y. Joseph Weiner, who was the only person in the factory at the time, was severely scalded. "The frame structure that contained the boiler was reduced to condition of kindling wood."

(105.) — On April 10th, a boiler exploded in Matthew Stevenson's tile mill near Veedersburg, Ind. John Dawson, an employe, was seriously scalded. The explosion "totally destroyed the building, together with a large amount of fine machinery."

(106.) — A terrific boiler explosion occurred, April 10th, in Labahn's brick factory, at Lansing, Ill. Fireman Joseph Seaman was killed, and the engine-room and boiler-house were completely demolished.

(107.) —A boiler in Hillerman & Son's feed mill, three miles northwest of Watkins, N. Y., exploded on April 11th. Gilbert S. Hillerman, who was standing near the boiler, was injured so badly that he died three hours later. William Osterhoudt was also seriously bruised and scalded. "The mill building was undermined by the explosion, and the roof fell in."

(108.) — On April 12th, a small boiler exploded in Louisville, Ky. David Taylor, the engineer, had a narrow escape from death.

(109.) —A boiler exploded on April 12th, at the wire cloth factory, in York, Pa. We did not learn particulars.

(110.) —A boiler exploded on April 15th, in Louis Emmons' mill at Foraker, Ind. James Stein and John Mathias were killed, and Joseph Mason, H. S. Emmons, and George Emmons were badly injured. Mason is not expected to live. "The explosion tore the mill entirely to pieces, and was heard ten miles away."

(111.) — One of the nest of boilers at the Corbin colliery, Shamokin, Pa., blew up on April 15th, wrecking the boiler-house.

(112.) — The boiler of a locomotive exploded, on April 16th, at San Jacinto, Cal. Engineer John Mills was killed. Fireman Jackson was scalded about the legs, and Brakeman Augustus Matthews was thrown about fifty feet, and painfully bruised. The wrecked engine proceeded about 500 yards down the track before coming to rest. Castings, tubes, piping, aad fragments of all kinds were thrown in every direction, and the engine was twisted into an indescribable mass.

(113.)—On April 20th, a boiler exploded at the New Venice Lumber Company's plant, near Scranton, Miss. The explosion occurred at 5 o'clock A. M., and the fireman and watchman, who were the only persons about, had just gone out of the boiler-house. The building was demolished.

(114.)—A hot-water boiler at "The Egnew" hotel, Mt. Clemens, Mich., exploded on April 22d. It passed up through the roof of the building. There were a number of narrow escapes, but nobody was hurt.

(115.)—The boiler in John Frank's egg-case and cheese-box mill, near Richland, Iowa, exploded on April 22d. A man named Condon was seriously scalded. The mill and its machinery were destroyed.

(116.)—A boiler exploded on April 23, in a mill owned by Peter P. Batte, near Petersburg, Va. Nobody hurt.

(117.)—On April 25th, fire broke out in the boiler-house of the Forty Fort Colliery of the Wyoming Coal Company, at Wilkesbarre, Pa. During the course of the fire one of the boilers exploded. The combined loss due to fire and explosion will reach $10,000.

Saturn's Ring.

In giving below, at the request of the editor of the *Courant*, an account of some recent observations of Saturn at the Allegheny Observatory, I have thought that a brief glance at the previous history of the subject would be of interest as an introduction; such a review is, indeed, necessary, in order that the reader may correctly understand the significance of the results which have been obtained at this place.

The hypothesis that the ring of Saturn is nothing more or less than a multitude of small bodies, revolving around the planet in circular orbits, is a very old one. It was suggested by Roberval in the seventeenth century, and was revived by Jacques Cassini in 1715, but in those days of course it had no better basis than mere speculation. These suggestions were forgotten, and when the great mathematician Laplace took up the question he regarded the rings as solid bodies. He arrived at the result that such rings could not exist in their actual form unless they were unsymmetrically weighted, and left the problem in this unsatisfactory state. At a later date Professor Peirce of Harvard showed that the rings could not be solid, and regarded them as composed of some fluid denser than water. Finally, the English physicist, Clerk Maxwell, discussed the whole matter thoroughly in a prize essay submitted to the University of Cambridge in 1857, and showed mathematically that the rings could be neither solid nor liquid, and that stable equilibrium would be impossible unless they were made up of separate bodies of no great size—"a shower of brickbats," he was in the habit of calling them.

It was indeed proved before Maxwell's time, by Edouard Roche of Montpelier, that a body of considerable size cannot revolve within a certain limiting distance of a planet, as it would be torn to pieces by the strain due to unequal attraction; but Roche's investigations were long overlooked. In the case of Saturn this "Roche's limit," as it is now called, is just outside the ring, and hence it follows that the ring must be made up of separate small bodies.

Thus it will be seen that the accepted hypothesis rested on a mathematical demonstration that no other constitution of the ring is possible according to the laws of mechanics, and although the mathematical proofs are conclusive to those capable of appreciating them, a proof by direct observation was regarded as having so much importance that the results obtained at the Allegheny Observatory attracted the widest notice.

If there were any spots on the ring, the matter would have been settled long ago; but there are none, and the motion of the ring was measured at Allegheny for the first time by means of a spectroscope. According to a well-known optical principle, a line in the spectrum of a heavenly body is displaced toward the violet if the body is approaching the earth and toward the red if the body is receding. Now, as Saturn's ring rotates, one side is continually moving toward the earth and the other side away from it. Hence the lines of the spectra in opposite sides of the ring are displaced in opposite directions, and by photographing the spectrum, and measuring the displacement on the photograph, we can determine the velocity in miles per second. The moon has no motion in the line of sight, and by photographing its spectrum on the same plate, without disturbing the apparatus, we have a starting point from which the displacements can be reckoned.

But this is not all; the velocity of different parts of the ring will differ according to the way the ring is made up. A satellite must move in obedience to Kepler's third law, and a consequence of this law is, that the velocity of the satellite varies inversely as the square root of its distance from the center of the planet; the nearer a satellite is to the planet, the faster it moves. It is easy to calculate that, if the ring is made up of satellites, its inner edge must move at the rate of 13.06 miles per second and its outer edge at the rate of 10.65 miles. If, on the contrary, the ring is solid, its outer edge must move faster than its inner edge, just as the tire of a wagon wheel moves faster than a point nearer the hub. The outer edge would in fact move more rapidly by about five miles per second.

Now let us see what the photographs say. Here are the main results obtained from the measurement of the two different plates:

Velocity of the middle part of ring, 11.2 miles per second.

Velocity of inner edge greater than that of the outer edge, 2 to 3 miles per second.

Comparing these figures with those given further above, we recognize that the photographs contain a proof that the ring is made up of independent bodies, revolving as satellites.

Perhaps I need hardly say that such results are not obtained as easily as they are described. Some idea of the delicacy of the observations can be formed when I state that a velocity of one mile per second causes a displacement on these plates of only one twenty-five thousandth part of an inch, and that the image of Saturn, which the telescope casts on the slit of the spectroscope, must not move much more than one three-thousandth of an inch during the long exposure of two hours. The plates are measured under a microscope, and while it is impossible to be certain of the fraction of an inch, an accuracy sufficient to decide in favor of the meteoric hypothesis of the constitution of Saturn's rings is quite readily attained.—Prof. James E. Keeler, in the *Western University Courant.*

The torpedo boat built at the Germania wharf at Kiel, Germany, for the Turkish government, was making her trial trip to Eckernfoerde, on May 27, when her boiler exploded. Six of the crew were instantly killed and four were mortally injured.

The Locomotive.

HARTFORD, JUNE 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

WE desire to acknowledge receipt of the twenty-fifth annual *Report* of the Norddeutscher Verein zur Ueberwachung von Dampfkesseln, of Hamburg, Germany.

WE have received from the Sulzer-Vogt Machine Company of Louisville, Ky., an illustrated pamphlet on "Electric Elevators," which discusses the system used by this firm. The pamphlet is issued as a supplement to their elevator catalogue, and copies of it may be had on application.

Perpetual Motion.

The search for perpetual motion is not so popular to-day as it used to be, but, nevertheless, it still goes on, and the United States patent office still receives applications for patents on devices that imply the solution of this famous problem.

In the days when the fundamental principles of mechanics were unknown, and it was believed that heavy bodies fall faster than light ones, even in a vacuum, there was nothing unreasonable in the hope that a machine might be devised which should furnish energy enough not only to keep itself going forever, but to run other machines also, and thus do useful work. Further study of the behavior of bodies and forces led to the discovery of certain laws of motion which clearly indicated the impossibility of solving the problem of perpetual motion by any combination of cranks and levers and gears, or by any arrangement of water-wheels and pumps. It is true that these laws have never been *proved*, and they cannot, from their very nature, be proved by any such rigorous process of reasoning as that employed, for example, in building up the science of geometry. It is safe, however, to judge them by their fruits — to take the position, in other words, that figs will not grow on a thorn tree. Looking at the question in this light, we see that all the great advances in mechanical arts have been based upon the assumption that the laws of motion, as now stated, are correct; and it is suggestive to note that whenever a machine is constructed so that it violates one of these laws, it does not work.

But the mad seekers after the elusive perpetual motion did not abandon their labors altogether when the new state of things came to pass. Some of them worked on, in sheer ignorance of the principles that had been discovered, and complained bitterly because better educated men would not listen to them, not argue with them. Others took refuge in the more recondite forces of nature. Driven from the field of simple mechanics, they sought, in the less explored fields of physics and chemistry, for principles that would accomplish what they began to perceive it was useless to search for in better explored regions. Electrical devices, in particular, were invented in great numbers. A favorite object of search was some sort of a shield that should be impermeable to *magnetism*, and motors were exhibited in which it was fraudulently claimed that such a screen had been discovered and applied. Even the usually astute editors of *Harper's Magazine* were deceived, a few years ago, by an invention of this sort, and they printed accounts and discussions of the discoveries of one Gary, until finally convinced of their error by an overwhelming weight of evidence from men educated along these lines.

As time has gone on, and the search has been prosecuted by thousands of men in every imaginable field of investigation, it has become increasingly evident that the problem is impossible. Although there may be nothing intrinsically unreasonable in it, thoughtful men have come to the conclusion that there is something about the perpetual motion which is incompatible with the general principles that underlie the universe as it is actually constituted. This is only another way of saying that it is as impossible to create or destroy *energy* as it is to create or destroy matter.

Thus we see that the search for the impossible perpetual motion has not been without fruit. The longed-for device has not been found, it is true, but in the course of the search the grand fact of the CONSERVATION OF ENERGY has been discovered. The search for the philosopher's stone, which should transmute baser metals into gold, and the equally vain search for the elixir of youth, were alike unsuccessful, so far as their avowed objects were concerned; and yet the alchemists who labored so patiently over these problems laid a substantial foundation for the modern science of chemistry. The old astrologers, too, who sought to trace human destinies in the configurations of the planets and the stars, were the pioneers of astronomy; and the indefatigable race of would-be squarers of the circle did good work in fostering the study of geometry and the infant science of trigonometry. Each of them strove for the unattainable, and yet their united labors were not lost. So, too, with the seekers for perpetual motion. They have studied, devised, and contrived for centuries upon centuries, and always with uniform failure; but they have contributed in no small degree to the establishment, upon an unshakable foundation, of the great doctrine of the conservation of energy — the grandest generalization of this century, or, perhaps, of any other.

Photography in Colors.

THE Royal Society gave its "ladies' soirée" on June 12th. The apparatus and experiments exhibited were of the usual variety and interest, but we shall confine our attention at present to Dr. Joly's exhibit, as described by our esteemed contemporary, *Engineering*.

"The greatest novelty in the rooms," says this journal, "was a set of photographs in natural colors, prepared by Dr. J. Joly of Dublin. The negatives are taken in the camera in the ordinary way, except that a ruled glass screen is interposed before the sensitive plate. This screen is ruled in fine ink lines in the three fundamental colors, red, violet-blue, and green, alternating all across the plate at the rate of 200 or more lines to the inch. The selective action of the screen makes itself felt on the negative, the result being that, except where pure white light falls, it also is divided into lines. From the negative a positive transparency is prepared, and when this is viewed through another screen ruled similarly to the first, but with somewhat different colors, the image is seen in the tints of the original object. It will make the matter clearer, perhaps, if we take a very simple instance. Let us suppose a photograph is taken, on a color-sensitive or isochromatic plate, of a sheet of paper of pure spectrum-red color. The red lines in the screen would allow the light reflected from the paper to pass, while the other lines would blot it out completely. When the negative was developed it would present a series of lines of clear glass, corresponding to the blue and green lines in the screen (through which no light proceeded), and a series of black lines of half the width, corresponding to the red lines in the screen. The positive would, of course, be the opposite of this; the red lines would be represented by clear glass, and the other colors by dark deposit. Now, if a three-color screen were placed at the back of such a transparency, with the red color superposed exactly on the clear glass and the two other colors on the opaque parts, it is evident that the plate would give a general red effect all over, provided that the lines were so fine that the eye could not divide the red and black streaks. Evidently the red of the last screen must be a different shade from the original paper, since the original color has been weakened by the action of the two screens. It is an easy step to go from a simple example like this to a geometrical pattern in three fundamental colors; and once the idea is grasped, it will be seen how the ordinary colors of nature can be portrayed, always provided (we should imagine) that photographic plates of uniform color-sensitiveness can be found. The process appears to be founded on the same idea as Mr. Ives's, but instead of three color-screens being used to produce three negatives, the screens are divided, so to speak, into fine shavings, the various colors being laid side by side to build up a single screen of alternate strips of red, blue, and green. Mr. Joly's photographs were shown in the lantern during the evening."

In referring to the soirée the New York *Sun* says, that Dr. Joly "exhibited a large number of photographic transparencies upon glass plates, representing various objects in natural colors. That every range of color and texture could be dealt with was evident upon examination of the subjects portrayed. The portrait of a gentleman seated on a garden seat showed the flesh tints of the hands and face with great naturalness. The straw hat upon the knee, the buff lining partly revealed within, as well as the faint green reflection on the rim where this caught the greenish light reflected from the foliage among which he sat, appeared reproduced with fidelity and realistic effect. Pansies of brilliant yellow and brown, deep purple, black, pale blue, snow white, and velvety brown, grouped in a painted china vase, appeared with equal fidelity in another picture. Other photographs showed the exterior of the red brick building of Trinity College, Dublin, fronted by a lawn with hawthorns, and above the greenish slates of the roof, the pale blue sky; the reproduction of a water color drawing of an Irish peasant girl wearing a red handkerchief over a blue dress, the warm and somewhat sunburnt flesh tints matching the original drawing with almost faultless fidelity, the original being placed above for comparison; a delicately colored Indian china and blue china lacquered; a brass microscope with highly reflecting German silver and copper lacquered finishing, and a thin uranium green glass tumbler with a subtle play of green and yellow light."

The screen used by Dr. Joly in taking most of the photographs referred to had 200 lines to the inch upon it. This ruling was found to be too coarse for some purposes, and he afterwards prepared screens with 300 lines to the inch. A group of flowers, photographed with this finer set of lines, was exhibited.

A KITCHEN boiler exploded at Minneapolis, Minn., on March 17, doing considerable damage. There were no personal injuries.

Effects of Temperature on the Strength of Wrought-Iron.

In our issue for May, we quoted, from *Engineering*, an account of some preliminary experiments made by Mr. Andrews, F. R. S., on the strength of iron axles subjected to an impact test at different temperatures. We are indebted to the same journal for the following account of Mr. Andrews' further experiments on the same subject:

In this second series of experiments a much smaller drop was adopted, and at the same time precautions were taken to cool the axles to be tested in a gradual manner. For this purpose the axle was placed inside an iron grating or cage, which prevented it coming into direct contact with the freezing mixture. The height of drop adopted was 2 ft. 6 in., while the weight used and span between bearings of axles were the same as in the previous experiments. For the warm tests the axles were placed in a water bath and slowly raised to 100° Fahr., and kept at this temperature for one hour before proceeding to break them. In each case the axle was after every blow replaced for 15 minutes either in the water bath or cold cage, as the case may be. The results obtained are given in the table:

TABLE OF RESULTS OF THE TESTS.

Cold Tests, 0° Fahr.						Warm Tests, 100° Fahr.					
No. of Axle.	Total Deflection in Inches.	No. of Blows Causing Fracture.	No. of Axle.	Total Deflection in Inches.	No. of Blows Causing Fracture.	No. of Axle.	Total Deflection in Inches.	No. of Blows Causing Fracture.	No. of Axle.	Total Deflection in Inches	No. of Blows Causing Fracture.
44	$4\frac{13}{16}$	8	77	$21\frac{5}{8}$	29	45	$13\frac{5}{16}$	23	74	$25\frac{15}{16}$	34
46	$5\frac{3}{4}$	8	78	66	84	47	$11\frac{7}{8}$	15	75	$12\frac{1}{16}$	16
48	$\frac{3}{4}$	2	79	$58\frac{3}{4}$	76	49	$19\frac{7}{8}$	23	76	$17\frac{1}{4}$	25
50	$6\frac{5}{8}$	8	80	$49\frac{7}{16}$	64	51	$14\frac{7}{16}$	17	81	$17\frac{3}{4}$	22
52	$8\frac{11}{16}$	11	83	$25\frac{7}{8}$	34	53	$21\frac{11}{16}$	22	82	$23\frac{3}{8}$	35
54	$38\frac{1}{16}$	44	84	$30\frac{1}{16}$	42	57	$71\frac{1}{16}$	107	89	$24\frac{1}{2}$	32
55	$4\frac{1}{2}$	6	87	$25\frac{1}{4}$	32	63	$9\frac{1}{16}$	12	85	$34\frac{3}{8}$	35
56	$6\frac{15}{16}$	10	88	$3\frac{3}{8}$	5	64	$31\frac{3}{8}$	49	86	$10\frac{5}{8}$	56
58	$7\frac{3}{16}$	9	90	$16\frac{1}{8}$	20	65	$32\frac{1}{8}$	44	111	$34\frac{5}{8}$	53
59	$5\frac{5}{16}$	7	91	$35\frac{7}{16}$	48	67	$40\frac{7}{8}$	54	98	$52\frac{3}{4}$	78
60	4	6	92	$8\frac{9}{16}$	12	69	$17\frac{15}{16}$	24	113	$30\frac{7}{16}$	45
61	$10\frac{5}{16}$	14	93	$7\frac{7}{16}$	10	70	$16\frac{7}{16}$	22	120	$23\frac{1}{16}$	32
62	$5\frac{9}{16}$	8	94	$3\frac{3}{8}$	5	71	$47\frac{1}{2}$	66	103	$34\frac{1}{2}$	49
66	$25\frac{3}{4}$	33	95	3	5	72	$43\frac{13}{16}$	62	121	$25\frac{15}{16}$	40
68	$26\frac{1}{4}$	32	96	$31\frac{1}{4}$	43	73	$37\frac{1}{2}$	57	108	$41\frac{1}{8}$	54
Averages of cold tests,				18.20	23.8	Averages of warm tests,				27.91	37.1

The tup weighed 1 ton, and the height of fall was 2 feet 6 inches.

It will be seen that on the average the warm axles were able to withstand about 50 per cent. more punishment than the cold ones; and that while of the warm axles no single one was broken under twelve blows of the tup, one of the cold ones was broken at the second blow, and about half of them broke with less than 12 blows. The best warm test is also much better than the best of the cold ones. The most remarkable feature of the test is, perhaps, however, the want of uniformity, considering that the quality was supposed to be the same throughout. Had steel axles, in an inspection test, shown such variation, there would have been good reason to reject the lot; but engineers in general are prepared to put up with variations in the quality of iron which would cause them to scrap the whole invoice, if of steel. This is, of course, justifiable enough, as there is no excuse for non-uniformity in the case of steel, the process of manufacture being so thoroughly under control. The difference in the two materials was very marked when the change from iron to steel became general in the boiler and ship yards. The percentage of plates rejected for defect fell at once.

In order to investigate more particularly the effects of sudden chilling, Mr. Andrews made a number of experiments in which iron forgings were slowed heated to different temperatures, and then rapidly chilled by being plunged in water. It was found that even when the range of temperature through which the sudden chilling took place was but 100° Fahr., there was a considerable difference in the bars cooled slowly and those rapidly chilled as described. This is a result which would, we imagine, have scarcely been anticipated, as most people would have expected the temperature range to be too small to show any material difference. As a matter of fact, however, the annealed forgings stood on an average of 23 experiments 31.7 blows each, with an average accumulation of the permanent deflections amounting to 18.83 in. The chilled forgings, on the other hand, stood on an average of 23 experiments 20.7 blows, with an average accumulation of deflections equal to 12.07 in. As before, individual results varied greatly. One of the chilled axles, indeed, stood 98 blows, while the best of the annealed ones stood but 71. Hence it is evident that a considerable number of experiments are necessary to get reliable indications. When the temperature from which the metal was chilled was equivalent to a red or white heat, the detrimental effects became very marked. In one case the forging failed at the first blow, while the strongest only stood 14 blows, and the average of 31 experiments was 2.42 blows only. The forgings used in these experiments were round bars 4½ in. in diameter, and 3 ft. 6 in. long between bearings. As before, the tup weighed 1 ton and fell 2 ft. 6 in.

It will be seen that none of Mr. Andrews' experiments have been made on steel, and until this metal has been examined in a similar way, it will remain a moot point as to how far the conclusion arrived at for iron will hold for steel. Every one is familiar with the important changes in the physical characteristics of a metal which may be caused by a small percentage of a foreign body. Thus ½ per cent. of lead added to gold renders the whole mass brittle, and iron is, if anything, still more sensitive to the action of small quantities of foreign bodies. Hence it must remain to a certain extent doubtful as to whether steel axles would act in a similar way to the iron ones. Certainly one would expect the results, whether favorable to the use of steel or the reverse to be very much more uniform, and not to show such extraordinary variations in the resistance of different specimens, as is exhibited in the above table. Considering the importance of the matter, and also the fact that steel is so rapidly replacing iron for axles, as well as for nearly everything else, it is to be hoped that some of our large steelmakers may see fit to continue Mr. Andrews' work, and extend his results to the more popular metal.

Mr. Webster's experiments, described in the minutes of the Proceedings of the Institution of Civil Engineers, Vol. LX, hardly cover the ground sufficiently, as the number of specimens of each particular metal tested was somewhat limited. The conclusion arrived at was that, in so far as ordinary tensile tests were concerned, both iron and steel were more ductile at low temperature, while their breaking strength was not reduced. With cast-iron, however, tested transversely, a diminution both in strength and flexibility was observed. With the impact tests, however, all the metals tried proved to be both weakened and less ductile at low temperatures. Colonel Greck, who spoke in the discussion following Mr. Webster's paper, stated that the Russian Government requires all acceptance tests of rails to be made at a temperature of about 2° below zero, Fahr. This gentleman also gave a table showing the results of some tests made at the Osnabruck Steel Works on 35-lb. rails, and it is interesting to note how much more uniform were the results obtained than in the experiments of Mr. Andrews. The maximum difference in the deflection of the specimens tested under similar conditions was, in the Osnabruck experiments, only some 8 per cent., instead of 35 per cent. or more, as in Mr. Andrews' experiments on wrought-iron. It is true that the results given by Col. Greck are only 12 in number, and perhaps greater differences would have been shown on a more extended investigation, but certainly we should be surprised if anything like the same amount of variation were found with steel as Mr. Andrews has observed in the case of iron. Whether iron or steel suffers the most from cold must be left for some future investigator to determine, and till then there is bound to be considerable difference of opinion between the makers of the two metals. Since, however, steel has suddenly displaced iron for railway axles, as for everything else, there is little doubt that our locomotive superintendents have concluded that it is now the more reliable of the two. The substitution in America has been hastened by the fact that iron-makers there have, it is stated, found it necessary to reduce the quality in order to compete with cheap steel, and complaints have been rife among the master mechanics of the great American railroads as to the difficulty of securing iron of the same quality as that furnished 16 or 20 years ago.

Acetylene.

The gas known as acetylene was first systematically examined by the French chemist Berthelot, in 1849, but until within a year or two it has been regarded more as a chemical curiosity than as a substance useful in the arts. This was because it could not be produced cheaply enough in useful quantities. In 1888 Mr. T. L. Willson began a series of experiments on the reduction of metallic oxides by carbon, in the fierce heat of the electric furnace. In the course of these experiments (which extended over a number of years) it was found that carbon and lime would unite at a high temperature, producing a substance which is known as carbide of calcium.

In a paper read before the Franklin Institute on March 20th of the present year, Mr. Willson gives some account of this body, and also of the now famous gas, acetylene, which is obtained from it. Carbide of calcium, he says, is a dark brown, dense substance, having a crystalline metallic fracture of blue or brown appearance, and a specific gravity of 2.262. In damp air it evolves a peculiar odor, but in dry air it is odorless. It is not inflammable, and can be exposed to the temperature of an ordinary blast furnace without melting. When exposed to the flame of a Bunsen blast lamp it can be heated to a white heat without suffering decomposition except on the surface, where it is reduced to lime. Its most striking property is, however, that notwithstanding its apparent stability and inertness, it decomposes water, at all temperatures, with great facility. The carbide consists of carbon and lime, and water consists of oxygen and hydrogen. When the two substances are brought together, the oxygen of the water combines with the lime of the carbide to form common slacked lime. This process liberates carbon from the carbide, and hydrogen from the water; and the interesting and commercially important fact about the reaction is, that the hydrogen and carbon thus set free immediately combine to form the hydrocarbon gas, acetylene. It is said that Mr. Willson discovered this reaction accidentally, through throwing a piece of hot carbide into a bucket of water, to cool it. We cannot say how this may have been. It really makes little difference whether the discovery was the result of accident, or of carefully planned experiments; for it is of great value in either case.

One pound of calcium carbide, when placed in water, produces nearly six cubic feet of acetylene (measured at the ordinary temperature and at atmospheric pressure). Mr. Willson states that the gas is colorless, and that it has "a penetrating, pungent odor somewhat resembling garlic, which is of great importance in its application to household illumination, as it renders the slightest escape of gas in a room easily detectable. It has a specific gravity (compared with air) of 0.91, and burns with a luminous, sooty flame." It can be liquefied without much difficulty. At a temperature of -116° Fah., it condenses under atmospheric pressure; and at 67° Fah. it liquefies at a pressure of about 40 atmospheres. The critical point of the gas (see THE LOCOMOTIVE for November, 1891) is about 98.7° Fah. If the liquefied gas be allowed to evaporate freely, the process of vaporization cools the remaining liquid so powerfully that it congeals into a snowy solid, whose melting-point is about 118° Fah. below zero.

According to Mr. Willson's figures, a thousand feet of acetylene will produce as much light as 12,500 feet of ordinary coal gas. This fact indicates very plainly the importance of the new process of manufacture. So far as the expense of working the process is concerned, we may say that Mr. Willson gives some highly seductive figures which tend to show that the manufacture of the gas by his method would be exceedingly profitable. We shall not discuss these figures, but we may say that they indicate that the process might be carried out commercially with a fair profit.

Considering the convenience of the gas, we shall expect it to come speedily into use. Of course it can be distributed in pipes, as coal gas is; but it possesses peculiar advantages for isolated places, such as country residences, since the calcium carbide can be transported in casks or otherwise, and all that is necessary to produce the gas is to wet the carbide. We see no reason why lamps could not be constructed, whose reservoirs should contain water, into which fragments of the carbide could be dropped when light was desired. Such lamps would give a brilliant light, and would be free from most of the objectionable features of those oily nuisances that consume kerosene. Such a lamp was in fact suggested by Mr. Willson himself.

Some Facts about Glass.

The most scientific glass workers of to-day are no more proficient in their art than were the craftsmen of ancient Thebes 4,000 years ago. These remarkable artisans, many of whom were priests high in authority, were well acquainted with glass staining, and displayed the highest artistic skill in their tints and designs. The colors were perfectly incorporated with the structure of the vitrified substance and were equally clear on both sides. The priests of Ptah, at Memphis, had a factory for the manufacture of ordinary glass, and also devoted their attention to imitating precious stones, succeeding so well that specimens now found require an expert to distinguish them from the real gems. They were also acquainted with the use of the diamond for cutting glass. A specimen of beautifully stained glass, now in the British Museum, has the cognizance of Thothmes III engraved upon it.

Spun glass was first brought into practical use about fifty years ago by Jules de

Brunfaut, a French chemist, although the art of spinning glass was practiced long before that time. He made a thorough study of the subject in Vienna. He first succeeded in softening the hard, shiny effect of the glass fabric, giving it a silky effect that was much more pleasing. Next he endeavored to reduce its brittleness by making a spun glass, whose threads were much finer than those of silk, and whose texture was much like that of wool. This glass could readily be woven and all kinds of articles were made of it. Among other things it was found especially suitable for surgical use, owing to its antiseptic properties and its cleanliness. The fact that glass is unattacked by most acids made the fabric useful for laboratory filters, and nearly all well-equipped establishments of the kind now use them. The cloth is, besides, non-combustible and a poor conductor of heat. As the individual fibers are perfectly non-absorbent, grease spots and stains can be readily removed. For this same reason the cloth cannot be dyed, but it can be spun of colored glass and the color is absolutely fast and unchanging.

Up to the beginning of the sixteenth century the glass used in stained glass work was what is known as "pot metal," that is, it was colored in mass through its entire substance. Painting was only used to bring out the shading and fine line work, and the paint was always brown, and was afterward "fired" into the glass. During the sixteenth century a rich yellow stain, obtained by the use of silver salts, came into use. It was also used upon blue glass to produce green effects. Shortly afterward the irregular depths of tint in the glass were first utilized to give modeling. The ruby glass used at this time was made by placing a thin layer of ruby "pot metal" upon the surface of a sheet of white glass and welding the two together by heat, as the ruby alone became opaque as soon as any thickness was reached. It soon occurred to some one to cut or grind away the ruby surface to produce white figures on the red ground. By staining the exposed portions, they were also able to get rich yellow and red contrasts. This led to extending the practice to other colored "pot metals," until a great variety of beautiful effects were produced.

When glass contains little or no lime it shows a marked tendency to become opaque upon cooling, probably owing to minute crystalization throughout its structure. The so-called alabaster glass is made by reheating glass of this kind and allowing it to cool slowly. Opalescent glass is that which possesses the same tendency in less degree. A good "mix," as it is called by glass workers, for alabaster glass is 100 parts of quartz sand, 45 parts of potash, 3 parts of calcined borax, and 5 parts of silicate of magnesia. —*Scientific American.*

In our esteemed contemporary, *Electrical Engineering*, we find the following parable, attributed to one Zambri, a Parsee :

"It is a waste of valor for us to do battle," said a lame ostrich to a negro who had suddenly come upon her in the desert; "let us cast lots to see who shall be considered the victor, and then go about our business." To this proposition the negro readily assented. They cast lots — the negro cast lots of stones and the ostrich cast lots of feathers. Then the negro went about his business, which consisted in skinning the ostrich.

All of which is supposed to illustrate the homely and familiar fact that a business agreement, although apparently equitable, may admit of a hidden construction which shall prove disastrous to one of the contracting parties.

The Locomotive.

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A Corroded Feed Pipe.

We present, herewith, a cut illustrating a remarkable case of corrosion that recently came to our notice. The pipe was of brass, an inch and a quarter in diameter internally, and about an eighth of an inch thick where the thickness was not reduced by corrosion. The feed-pipe entered the boiler from the top, through a bushing, and the brass pipe here illustrated was screwed into this bushing on the inner side of the boiler, so that it stood in a vertical position, with its lower end (to which the elbow is attached) below the water line and just above the tubes. A horizontal iron pipe, screwed into the elbow of the brass pipe, then conducted the feed-water toward the rear of the boiler, the rest of the piping being arranged as recommended by this company. The brass pipe was very much corroded, as shown in the illustration, and yet the iron pipe that was screwed into it was quite unaffected.

The boiler in question was situated in a shoe-shop in Massachusetts, in a part of the state where the water is more or less hard, soda-ash and kerosene being used to prevent the accumulation of scale. The boiler was three years old, and the brass pipe had been in use for the same length of time.

CORRODED BRASS PIPE FROM THE INTERIOR OF A BOILER.

The feed-water was drawn from the town supply, and was heated by a coil heater, by exhaust steam. It was metered, and naturally enough an effort was made to economize in the consumption of it, so far as possible. The drips from the shop were all returned to the feed-tank, together with the condensed water from the heater. As a result, a considerable quantity of greasy matter was introduced into the boiler along with the feed, and some trouble was experienced through the starting of the girth joint over the fire. The drip from the heater was then disconnected from the feed-tank, and allowed to run to waste. This prevented the introduction of grease, so that the boiler became much cleaner, and no further trouble was had with the joints. The change was made last January, and the boiler was not inspected internally at that time, so far as we are aware.

The large hole in the corroded brass pipe came just at the usual water line, and the natural inference would be that the destruction was due to the corrosive action of the floating grease, which would be gradually decomposed by the heat, with a corresponding liberation of the fatty acids it contained. There are several objections to this hypothesis, however. In the first place, the pipe was in good condition when the last internal inspection was made, a year ago, although it had then been exposed to the grease two years. Twenty-four months of exposure had not noticeably affected it, and yet the seven months that elapsed between the last inspection and the disconnection of the heater had entirely destroyed it (assuming the grease theory to be correct). Again, there is another boiler in the same room, eight years old, which also has a brass pipe in it, arranged in the same way. There is no observable difference in the conditions under which the two boilers are run, nor in the manner of feeding them; and yet the brass pipe in the second boiler, which is five years older, is far less affected, although it does show signs of the same action. The shell-plates along the water line are perfectly sound in both boilers, with no indications of pitting or corrosion.

It has also been suggested that the action was of electrical origin, and that it was due either to the dynamo in the next room, used for lighting the shop, or to the simpler fact that the feed-pipe was constructed of two metals, brass and iron, which would naturally produce a galvanic couple when submerged in the water of the boiler. In support of the first view it is alleged that the corrosion dates practically from the time the electric lights were introduced; and yet it is hard to understand how an electric action from such a cause could take place within the closed conductor formed by the boiler shell.* If the corrosion were of electrical origin, it seems more likely that the source of the electricity was *within* the boiler; but in that case we fail to understand why it was not observed before.

As may be inferred from what has been said, we are not prepared to offer any conclusive theory with regard to this particular case of corrosion. The brass pipe here illustrated has been replaced by an iron one, while the corresponding brass pipe in the neighboring boiler has not been disturbed. The conditions under which the two boilers are run have not been otherwise changed, and it will doubtless be instructive to observe the subsequent course of events.

In conclusion we may say that in our judgment brass should never be used, either for *internal* feed-pipes, or for blow-offs. It does very well for external feed-pipes, which are not exposed to heat, but in other places it cannot be recommended. Iron is much better.

A GOOD example of the absurd kind of talk that is sometimes addressed to royal personages is given by an esteemed contemporary. A chemist was lecturing before a king, and at a certain stage in one of his experiments he paused and said, "These gases will now have the honor of combining before your majesty."

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* [Faraday made elaborate investigations of the electrical condition of the interior of a conductor which was charged on the outside with electricity. In the course of one of his experiments, he built a large hollow cube, twelve feet square, and covered it all over, on the outside, with copper wire and tin foil. He took delicate electroscopes into the cube, but could not detect any electricity at all, even when the outside was strongly charged. "I went into the cube and lived in it," he says, "and using lighted candles, electrometers, and all other tests of electrical states, I could not find the least influence upon them, or indication of anything particular given by them, though all the time the outside of the cube was powerfully charged, and large sparks and brushes were darting off from every part of its outer surface." (*Experimental Researches in Electricity*, by Michael Faraday, Vol. I., page 366.)]

Inspectors' Report.

MAY, 1895.

During this month our inspectors made 8,316 inspection trips, visited 15,960 boilers, inspected 6,946 both internally and externally, and subjected 755 to hydrostatic pressure. The whole number of defects reported reached 12,046, of which 1,092 were considered dangerous; 82 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	978	52
Cases of incrustation and scale,	2,140	92
Cases of internal grooving,	118	22
Cases of internal corrosion,	785	36
Cases of external corrosion,	846	56
Broken and loose braces and stays,	128	60
Settings defective,	328	31
Furnaces out of shape,	473	32
Fractured plates,	328	55
Burned plates,	267	61
Blistered plates,	264	14
Cases of defective riveting,	1,162	49
Defective heads,	129	16
Serious leakage around tube ends,	2,110	257
Serious leakage at seams,	533	36
Defective water-gauges,	437	77
Defective blow-offs,	193	64
Cases of deficiency of water,	12	5
Safety-valves overloaded,	46	12
Safety-valves defective in construction,	76	14
Pressure-gauges defective,	598	43
Boilers without pressure-gauges,	8	8
Unclassified defects,	87	0
Total,	12,046	1,092

Boiler Explosions.

MAY, 1895.

(118.) — As the train on the W. C. & C. R. R. was within about three miles of Conway, S. C., on May 2d, the boiler the locomotive exploded. The fireman jumped from the engine and broke his leg; but the engineer, who remained within the cab, was not injured. The locomotive was practically destroyed.

(119.) — A large boiler at the Knoxville rolling mills, Knoxville, Tenn., exploded on May 4th, doing great damage to the property. Fortunately, nobody was killed.

(120.) — A boiler exploded, on the morning of May 7th, in John Bennett's saw-mill, near Kokomo, Ind., just as the men were beginning work in the morning. The engineer, James Catt, was killed, and Frank Downing, Fred. Phillips, and John Bush were injured. Downing's injuries are fatal. The mill was blown to fragments, and the boiler was thrown 500 feet. A schoolhouse across the road was injured also.

(121.) — A heating boiler exploded, on May 7th, in the basement of St. Mary's School for Girls, at Concord, N. H. The foundations of the building were injured in several places, the floors were bulged upward, the windows were shattered, and the furniture was thrown all about. Miss Gainsforth, principal of the school, who was in her room when the explosion took place, was thrown to the floor, and fainted with fright. Twenty-five young women were asleep in the building at the time of the explosion, and it is considered remarkable that none of them were injured.

(122.) — The boiler of a traction engine exploded in the yard of Walter S. Trew, of Quaker Neck, near Chestertown, Md., on May 8th. The men were at dinner when the explosion occurred. The engine was completely wrecked, and a meat-house, twenty feet away, was moved about six feet. Other property was also damaged.

(123.) — The boiler of a locomotive attached to a freight train on the Pan-Handle-Chicago line, exploded May 13th, near Winnimac, Ind. John Long, a brakeman, who was riding in the cab, was dangerously scalded. P. J. Kinner, the fireman, was also severely injured, but A. W. Knight, the engineer, escaped without material harm.

(124.) — The river steamer *Unique* left Detroit, Mich., for Port Huron, on May 13th. When about nine miles from Belle Isle, on Lake St. Clair, one of the tubes in her safety boiler failed, and clouds of steam and soot were driven up through the hatches with terrific force. Engineer George Robinson, who was sitting on the port rail at the time, was blown overboard. Life preservers were at once thrown to him, but as the boat was going at full speed they did not come within his reach. A boat was lowered as soon as possible, and a thorough search for him was made, but he could not be found. When the steam had cleared away sufficiently, the officers of the boat went down to the boiler-room. On the floor lay Anthony Case, a coal passer, who was killed outright, and near him was John Plant, who was fearfully burned.

(125.) — A boiler in the thirty-three inch mill at Homestead, Pa., exploded on May 14th, fatally scalding Theodore McHenry and seriously injuring James Anderson. The men were both scalded and bruised by flying debris. The buildings near by were damaged to a considerable extent. Parts of the roof and walls of the boiler-house were blown in all directions, some large pieces of the roof being carried 100 feet from their original positions.

(126.) — The boiler in the electric light plant at Sleepy Eye, Minn., exploded shortly after midnight, on the morning of May 14th. The plant was in the basement of the high school building, a fine structure which cost over $27,500. All that now remains is a shapeless mass of ruins. The engineer of the electric plant had left the building at 11.45 P. M., with 60 pounds of steam in the boilers, and the explosion occurred 35 minutes later. The concussion was felt more or less for a radius of three miles. The building took fire immediately, and nothing was saved from it. The electric light apparatus, which cost about $9,000, was entirely ruined.

(127.) — On May 14th a boiler exploded near Coudersport, Pa., in the saw-mill of Peck, Haskell & Cobb Bros. Claude English, James Mowers, Eugene Merrick, Lyman Perry, and Charles Grover were instantly killed, and Caleb Converse, John DeGrote, and Adelbert Gudley died within a few days. Several persons were also injured and the mill was wrecked. Thirteen men were employed in the mill, and at the time of the explosion the mill was shut down while a belt was being repaired. "Nobody paid any attention to the boiler, which was making steam at a prodigious rate. It was nobody's business in particular to look after the boiler, everybody took a hand occasionally in firing, and except when the engine was started or stopped, little or no attention was paid to the steam. Suddenly there came a boom as if a cannon had been fired, followed by a cloud of steam, dust, and smoke, which rose high in the air. Four of the victims were torn limb from limb, and were recognizable only by their clothing. The mill was almost entirely demolished, and parts of the boiler were blown hundreds of feet."

(128.) — On May 14th a boiler exploded on the steamer *Rescue* as she was going up the Monongahela River, near Pittsburgh, Pa. The accident happened just as the *Rescue* was passing through lock No. 1. The explosion consisted in the collapse of a flue. The engineer, George McGinniss, and the fireman, Claude Schoonoder, were fearfully scalded, and it is believed that McGinniss will die.

(129.) — A small hot-water boiler in John Maginty's barber shop on Washington Street, Boston, Mass., exploded on May 15th. The barber shop and a kitchen in the rear of it were wrecked, but, as the explosion occurred at about 2 o'clock in the night, nobody was hurt.

(130.) — A blow-off pipe blew out, on May 15th, in Wherry Bros.' mill at Overton, Rusk Co., Texas. Mr. M. L. Wherry, one of the owners of the place, was severely scalded.

(131.) — A boiler exploded on May 16th, at the Green Ridge colliery, near Mt. Carmel, Pa. Engineer James Brennan, Fireman Joseph Boluta, and a laborer named George Rolala were badly burned about the face, hands, and back.

(132.) — Charles Pickett was killed, on May 16th, by a boiler explosion in Hiram Reynolds' quarry at Medina, N. Y. He was in the engine-house repairing a valve, and was struck on the head by a fragment of the boiler.

(133.) — A well was being drilled at Charles Peterson's residence, Attica, Ind., on May 17th, and during the progress of the work the boiler that was operating the drill exploded. William Smith was instantly killed, and Frank Peterson received injuries from which he died within twenty minutes. Leonard Stambaugh was also fearfully scalded, and cannot live. J. W. Hamar, Alexander Hamar, and Henry Shumar received lesser injuries.

(134.) — A boiler exploded, on May 19th, at the Mederia Coal Company's plant at Vinton, near McArthur, Ohio. The engineer had left the building about two minutes before the explosion. The boiler-house was completely wrecked.

(135.) — One of the boilers in the electric light plant at Valdosta, Ga., burst on May 22d. Nobody was hurt.

(136.) — A serious accident occurred on May 27th, about a mile from Labadieville, in the parish of Assumption, La. Messrs. Elfert and Delmonte, who were working a tract of land on the Tete plantation in rice, had erected a pump for irrigating the fields. On the day referred to the boilers exploded and were thrown in every direction. Charles Elfert had his jaw broken, and received other injuries about the head and face. Emile Adam had an arm broken. Lestain Hebert was slightly scalded, and a Mr. Maillet was thrown into Bayou Lafourche, from which he came forth without injury.

(137.) — On May 27th one of the four big boilers in Strickland, Wesley & Co.'s mill at Point Washington, Fla., exploded and was carried about 200 feet. The account we have received says that "not one of the fifty men in the mill was hurt, and even the ancient mule that furnishes the motive power for the sawdust cart, though almost hidden for a time by flying ashes, mortar, and brick-bats, only switched her tail in probable wonderment at the extraordinary size of the mosquitoes, and pursued the even tenor of her way."

(138.) — A boiler exploded, on May 28th, in a mill owned by Messrs. Killian & Teague of Lenoir, near Taylorsville, N. C. Edward Deal, Pender Oxford, and Gordon Oxford were instantly killed, and Reuben Jones was hurt so badly that he died five hours later. Two other men were seriously bruised, but will recover.

(139.) — Engineer Charles Mitchell was horribly scalded and otherwise injured, on May 29th, by the explosion of a boiler at Upson's coal works, Shawnee, Ohio.

(140.) — The large boiler in A. J. Collinsworth's mill, two miles west of Humboldt, Tenn., exploded on May 29th, making a complete wreck of the whole place. Several men were at work in the mill at the time, but no one was hurt.

(141.) — A boiler exploded on May 29th in the office of the Garrettsville *Journal*, Garrettsville, Ohio. Editor Charles B. Webb was injured seriously, and perhaps fatally. Miss Nellie Bosley was also slightly hurt. The building was badly shattered, and the machinery about the place was considerably damaged.

(142.) — A mud-drum on one of the boilers in Blythe & Co.'s mill at Monongahela, Pa., gave way on May 30th. John Webb was severely scalded about the head and body. Anson Hillman was also seriously scalded, but both men will recover.

(143.) — A boiler exploded on May 30th in a brickyard near Abita Springs, La. Two men were killed, and several others were injured. We did not learn further particulars.

THE boiler of the Ecuadorean gun-boat *Sucro* exploded at Guayaquil, Ecuador, on the night of May 30, killing the commander and fourteen men, and injuring seventeen more, thirteen of them fatally. At the time of the explosion she was carrying troops to Machala to attack the rebels.

A BOILER exploded, on June 22, at Kiel, Germany, on a steam launch belonging to the United States cruiser *San Francisco*. Three men were injured.

SEVEN persons were also killed, and several others wounded, on June 28, by the explosion of a boiler on a steam launch belonging to the German war-ship *Kurfuerst Friedrich Wilhelm*, at Holtenau.

A BOILER explosion at the Red Car iron works, near Guisborough, Yorkshire, England, on June 15, resulted in the instant death of six persons, and serious injury to eighteen others. Three of the injured persons died later in the day, making a total of nine killed. Thirteen out of the fifteen boilers exploded. The brickwork of the settings was hurled in every direction, and an immense volume of boiling water was discharged over the workmen. The damage done will amount to about $250,000. The latest reports from the scene of the disaster indicate that, in addition to the nine persons killed, *twenty* were seriously injured. Four hundred men were also thrown out of work.

The Locomotive.

HARTFORD, JULY 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

THIS world is a difficult world indeed,
And the people are hard to suit;
And the man who plays on the violin
Is a bore to the man with the flute.

And I myself have often thought
How very much better 'twould be,
If every one of the folks I know
Would only agree with me.

But since they will not, the very best way
To make this world look bright,
Is never to mind what people say,
But to do what you think is right. — *South Wales Echo.*

THE camel is the animal that is oftenest mentioned as an example of one in which thirst is the longest endured. But Mr. S. M. Gorman of Cambridge, Mass., writes to *Nature* that more striking cases of prolonged endurance are found in a number of small rodents that inhabit the arid plains in the vicinity of the Rocky Mountains. These animals live for weeks and months without meeting with a single drop of water. The sand is torrid, the entire vegetation is burned up, and yet they resist. This is not the result solely of observations in nature, for direct experiments, pointing to the same conclusion, have also been made. Some common mice were put apart on the first of last October in cages in which they received nothing but perfectly dry food, such as Indian corn and grass seeds. On the seventeenth of January they were in perfect health and seemed as if they would continue thus for a long time, although they had not received a single drop of water or of any other liquid in the interim.—*Scientific American.*

SOME one has called the mule the best soldier we had in the war. It is certain that the service he rendered is beyond calculation. Some teams were conspicuous, as witness the history of the following : It was fitted out in Berryville, Md., in April, 1861. A year later it was transferred to Washington, and in May was sent to Fort Monroe to join McClellan's army. It followed the latter up the Peninsula, was at the siege of Yorktown, the battle of Williamsburg, and in the swamps of the Chickahominy. Participating in the Seven Days' battles, it finally brought up at Harrison's Landing, whence it went back to Washington. It then hauled ammunition for the second battle of Bull Run, followed the army to Antietam, and from there to Fredericksburg. When General Hooker took command of the army it went with him through the Chancellorsville fights. In 1864 we find it at City Point with Grant. It served with him until the war closed, and a year later was in Washington as ready for duty as ever. The team was frequently without a bite of hay or grain for four or five days at a stretch, and nothing to eat but what it could pick up by the wayside. There were times also when it went without water for twenty-four hours. Those mules should have been tenderly cared for during the rest of their lives, and never worked except for exercise.—*New York Sun.*

The Growth of Plants.

Many persons who have but little taste for science in general derive much pleasure from the study of botany. This is partly because the beauty of the flowers commands attention even from those who are ordinarily thoughtless of Nature, and partly, no doubt, because of the stimulus given to such study by Asa Gray. The works of this eminent man, although wonderfully profound and complete in their way, have had the unfortunate result of directing popular study towards the least interesting of all the branches of botany; for we find ninety-nine out of every hundred of its devotees so absorbed in the identification and classification of plants, that they give scarcely a thought to anything but *morphology.* When the average student has examined a flower and observed the arrangement and form of its leaves, the structure of its calyx and corolla, the number and mode of insertion of its stigmas, the geometry of its buds, and a few other things of this sort, he pronounces its name with a certain degree of satisfaction, and (if his enthusiasm goes so far) he squeezes the life out of it in a press, gums its dried remains upon a card, and looks about for his next victim.

Such work is doubtless useful, but we cannot say that we find it particularly interesting. Generations of students might pass by without materially advancing our knowledge of the plant world, if their study were all of this kind. The true secrets of botany must be unraveled from the *living* plant. How does it grow? Why is it green? Why does it blossom? How are its seeds scattered abroad? and how and why do they sprout? These are some of the multitude of questions that press upon us for solution; and none of them can be answered from the herbarium. They lead us rather into the fields and the woods, and into the laboratory.

We cannot answer any of them, yet, with anything like completeness. We know, however, that the great law of the conservation of energy is as true for the vegetable kingdom as it is for the mineral kingdom; and this fact must ever be our guiding light in the study of botany in its broader sense. We know that plants are combustible, and that by burning them under boilers we can generate steam, and run engines. We know, too, that we cannot do this with the soil and carbonic acid gas of which they are built up. It follows, therefore, that the plant has contrived somehow to *gain energy.* It cannot manufacture energy, any more than a wind-mill can; and hence it must have absorbed it from something else. Several sources of energy are available, but all the higher plants obtain their supply directly from the sun, by means of the green coloring matter (chlorophyll) in their leaves; and thus we see that the prevailing tint of our vegetation is no mere accident, but that it is a consequence of the law of the conservation of energy. If the leaves of a green plant are examined under a microscope, it will be seen that the coloring matter is not diffused throughout the tissue, but that it occurs only in little bright grains, which are called chlorophyll corpuscles. When the sun is shining these corpuscles absorb the energy of the sunlight in some way which is not yet understood, and by means of the energy so obtained they are enabled to perform marvelous chemical feats, only the simplest of which can yet be imitated in our laboratories.

Carbonic acid gas, which is produced when coal or wood are burned, and which is also thrown off from the lungs of animals, is always present in the air to some extent. This gas is greedily seized by the chlorophyll corpuscles with which it may come in contact as the breezes blow through the foliage of the plant, and is split up into its constituent parts by means of the energy which the chlorophyll is meanwhile absorbing from the sun. The carbon of the gas is retained, and the oxygen is allowed to escape again into the air. Carbon and oxygen are bound together most powerfully in the molecules of carbonic acid gas, and in order to separate them the chemist has to use the utmost resources of his laboratory; yet the chlorophyll corpuscles of the plant, by the aid of the supply of energy obtained from the sun, are enabled to effect this most difficult separation with the greatest ease.

It will be seen that in sunlight green plants are constantly absorbing carbonic acid and giving out oxygen, while in animals the action is precisely the reverse. In the night-time, however, it is found that plants absorb oxygen and give out carbonic acid, and it is thought probable that both of these actions go on together in the daytime, the liberation of carbonic acid being masked, however, during sunshine, by the more copious liberation of oxygen. It is practically certain that no life can exist under any circumstances without being accompanied by the continual oxidation of carbon ; the energy made available by this oxidation being that which produces the phenomena of life itself.

The leaves are the laboratories in which the substance of the plant is built up. They have many functions to perform, in addition to the decomposition of carbonic acid, which we have just considered. For example, they serve as an evaporating surface. It is difficult to realize how great this surface is, in the case of trees especially. In a good-sized oak tree the united area of the leaves probably amounts to thousands of square feet, and as the leaves are hung up in the breeze, it is easy to see that they are very efficient in promoting evaporation. As the moisture in them dries out, it is highly important that more water should be supplied to them from the tree itself ; for otherwise they would quickly wither, and before long would become dry and dead. The water which is thus necessary in order to keep them in good condition, is absorbed from the ground by the roots of the plant, and carried up to the leaves by conduction along the wood-fibres.

It was formerly thought that the sap of the plant was carried upwards from the roots by means of capillary attraction. This view is no longer tenable, because it is easy to show that in the case of tall trees like the red-woods of California, the capillary passages would have to be far smaller, in order to raise water to such a height, than any which exist in the structure of the red-wood tree. We now know that the sap does not rise through little tubes in the wood, nor through the spaces between the woody fibres ; but that it travels directly through the substance of the wood itself. The peculiar sensitiveness of wood to moisture is well known to the carpenter and the cabinet-maker, and when the wood is in its fresh, or so-called living state, its affinity for moisture is immeasurably greater. If a piece of fresh wood be dried at one end while the other end is kept immersed in water, the water passes through it very rapidly, almost as though it were a sponge. We have to regard the leaves of a plant as united to the roots by the woody fibres in such a way that when the leaves are dried slightly, more water is immediately conducted to them directly through the woody matter, and against the action of gravity. The elevation of water in this way might seem at first sight to be contrary to the principle of the conservation of energy. That this is not the case is shown by the fact that more heat is required to evaporate water which is absorbed by woody tissue than is required to evaporate the same amount of water in the free state. The potential energy of the raised water has been increased, so far as gravity is concerned, but its *chemical* potential energy has been decreased, at the same time, by its combination with the wood. There has, therefore, been merely a *transformation* of energy, from the chemical form into the gravitative form.

Before returning to the leaves, let us say a word about the absorption of water by the roots. If the roots of a plant be carefully observed, it will be seen that in addition to the larger branches there are innumerable other minute appendages which are called root-hairs, and which pass out into the soil in every imaginable direction. The chief function of these root-hairs is to absorb the moisture with which they come in contact, *together with such mineral matter as may be dissolved in it.* The moisture thus absorbed by the hairs is passed onward to the roots themselves, and it then soaks upward through the plant, as we have seen, as the evaporation goes on in the leaves. But the root-hairs do not act simply like so many fibres of blotting-paper; they have other functions which are not yet fully understood. If a seed be planted in shallow earth over a polished plate of marble, the roots, when they have grown down far enough to lie along the surface of the stone, will etch it away so as to leave quite a sensible imprint. This shows that the root secretes some sort of corrosive substance, which is probably designed to aid it in dissolving such mineral matters as may lie in its course. As the roots of the plant extend further into the soil, the root-hairs near the stem die, and new ones are continually formed, further out, where they will come in contact with fresh portions of soil.

It is important to note that the moisture which is absorbed by the roots and passed up to the leaves does not consist of *pure water.* It is, instead, a dilute solution of mineral matter. The watery part of it evaporates in the leaves, while the dissolved matter remains behind, and accumulates in the leaves until it becomes nearly enough saturated to be available for the purposes of growth. From this mineral matter, together with the carbon that has meanwhile been separated from the carbonic acid of the air, the chlorophyll corpuscles, still drawing energy for the purpose from the sunlight, build up substances of great chemical complexity. We do not know the steps by which this is done, but the first thing that we can perceive, as a result of the action of the chlorophyll — "the first obvious product," as Sachs calls it — is *starch.* The presence of starch in leaves is easily shown. For this purpose the leaf should be picked late in the afternoon of a sunny day, and it should then be boiled in water for a period of from ten minutes to half an hour, according to the thickness and texture of the leaf, thin leaves requiring less time than fleshy ones. After the boiling (the object of which is to kill the tissue, hydrolyze the starch, and break up the cell-walls somewhat) the leaf should be soaked in 95 per cent. alcohol until the chlorophyll is extracted, and the leaf rendered colorless. A dilute solution of iodine in weak alcohol will then reveal the presence of starch by the formation of the blue iodide of starch.

Starch, as is well-known, is insoluble in water; and before it can be used in the plant it must be transformed into a soluble sugar. It is not likely that the starches and sugars are identical in all plants, but in most cases the sugar which is formed is probably closely similar to the substance known in trade as glucose. The transformation of starch into sugar is easily effected by the action of ferments, which may be present in very small quantities. (The presence of such ferments in the leaves of plants has been shown by direct chemical tests.) The sugar, when formed from the starch, dissolves at once in the moisture or sap of the plant, and is then diffused everywhere through the tissues by the process known as osmosis, which is described and discussed in all the books on physics. There is a close analogy here between plants and animals. When an animal eats starchy matter the starch is transformed into sugar by means of the saliva and pancreatic fluid. The sugar thus produced is dissolved, and passes through the intestine and into the general circulation, by the same process of osmosis that occurs in plants. Once in the blood it is carried to the liver, where it is transformed into a starch-like substance called glycogen, and the supply thus stored up is drawn upon as the system may require it. In precisely the same way the sugar in plants is transformed back into starch and deposited in the seeds, and in other special receptacles, which may be within the stem of the plant, or attached to the roots. Corn, wheat, and grain of all kinds furnish illustrations of starch deposited in the seeds, and the potato, turnip, and beet are familiar examples of the storage of starch in the roots.

We do not know precisely how the plant makes use of the sugar that its sap holds in solution,— that is, we do not know the precise process by which this sugar is transformed into plant-tissue; but the transformation occurs at certain points which are called growing points, and the action appears to be not unlike that which takes place when a crystal of some substance is forming from a solution. The analogy is not at all perfect, because in the crystal there is supposed to be no change in the chemical nature of the substance which is deposited, while in the plant the sugar is built up into the most complicated substances that we know of, including that elusive body, "protoplasm," which is so firmly united, in the minds of the laity, with the name of the late Professor Huxley.

We cannot go further into the chemistry of plant-growth, without making this article of unreasonable length. We have touched briefly on one of the interesting branches of the great science of botany, to illustrate the point that we made at the outset — namely, that the subject, as ordinarily studied, is dry and dusty, and that there are hosts of profound problems about plants, which can only be answered by observing the plant as it grows, or by examining it in the laboratory. In conclusion, we may say that compound microscopes and other expensive apparatus, although desirable, are nevertheless not *necessary* to one who would study the "higher botany." Many of the deeper secrets of the flowers — those relating to the forms of the blossoms, for example, and to the distribution of seeds — will have to be solved by patient watching in the fields; and there is plenty of room here for original work by any earnest student — work, too, which cannot be done by post-mortem examinations of the cadavers to be found in the conventional herbarium.

A SINGULAR fact is recorded in the *Moniteur Industriel*, namely, that on the shores of Brittany, between St. Malo and St. Lunaire, in the vicinity of the St. Enogat station, at a place called Port Blanc, the tides have lately displaced a considerable amount of sand, say to a depth of some nine to thirteen feet. Accompanying this remarkable phenomenon is the fact that forests known to have been buried for periods covering some eighteen or twenty centuries have now been brought to light, and a vast forest has, it appears, been discovered in process of transformation into coal; ferns and the trunks and barks of trees are to be seen in an advanced state of decomposition, being already beyond the peat formation, showing, in fact, the films and flakes which are found in coal, and, while some of the trunks are sixteen feet in length, and still very distinct. they are becoming rapidly transformed. — *New York Sun.*

WHILE the Italian torpedo boat *Aquila* was undergoing trials, near Spezzia, Italy, on July 3, her boiler exploded. Five men were killed and thirteen injured. The other six men aboard of her escaped injury.

Technical Research.

Every engineer is engaged in technical research, sometimes at his own expense, but oftener at the expense of his clients. The more important and commanding his position the greater is the proportion of his work that lies outside the boundary of assured knowledge. The ordinary everyday problems in construction are confided to the journeymen of the craft, who, out of the records of their experience, can generally find a fitting solution, or can even go one step in advance of what has been done before. But when not one, but many, stages have to be traveled into the unknown, there is needed something more than a general knowledge of the subject, and fair ability to reason by induction. Then it is that the real art of the engineer — an instinctive power in adapting the forces of nature to new ends — comes into play. If the matter be one dealing with machinery, it is generally possible to try small-scale experiments in regard to a few, if not all, of the points of issue, and thus to eliminate some of the doubtful points in the subject. But there are many matters that are submitted to engineers the difficulty of which arises mainly from their magnitude, and which have to be treated entirely from a new standpoint. Only full-sized experiments would be of use, and therefore the whole affair becomes a gigantic piece of research work, for which the promoters find the funds, and on which the engineer stands to gain or lose reputation. Generally he gains it. It is perfectly wonderful with what a large measure of success new and difficult work is accomplished, and how exceedingly few are the serious failures. The mishaps that do occur are mostly connected with details that could be studied on a small scale if the engineer had time and money to investigate them. But while promoters will risk tens of thousands of pounds on a project, it is practically impossible to get them to provide a few thousands to be spent solely in acquiring knowledge on points that are apparently of subsidiary importance. They consider that technical research is no part of their business, and they decline to spend money in increasing the general stock of knowledge, although the first fruits would be reaped by themselves.

Great advances in engineering practice wait more often upon details than upon principles. The conception of the compound marine engine is old enough, but it was not until a satisfactory surface condenser was produced that it became commercially possible. As long as the boiler was fed direct from the sea, thirty pounds per square inch was the limit of practicable pressure, and compounding offered no advantage under this condition. The surface condenser, as now made, is a simple enough affair, yet it took many years to arrive at, because neither marine engineers nor shipowners were willing to spend the necessary money over a series of comparative experiments. Occasionally a sanguine individual ventured to try one, and when he found it unsatisfactory he generally preferred to face the known loss of abandoning it rather than enter into a series of experiments to perfect it. The triple-expansion marine engine furnishes another example. Up to about 1881 there was scarcely an engine of this kind constructed, and after that date there were very few built of any other kind. The deterrent cause in this case was a misgiving as to the possibility of finding a satisfactory material for boilers carrying 160 lb. to 180 lb. pressure, and complying with the requirements of marine service. Shipowners held back from making experiments for the benefit of the trade. For years they stuck to the compound engine, well knowing that a 20 per cent. economy was available, if only certain preliminary difficulties, by no means insuperable, could be overcome. But, naturally, no one was willing to pay for experience that would be immediately public property.

It is only under the protection of a patent that a manufacturer can afford to institute researches and pay the cost of experiments. It is a matter of common knowledge that some subjects which it would be advantageous to the public to have pursued, are allowed to sleep because it is known to be impossible to secure a broad patent for any improvements that may be devised in connection with them. In years past attempts have been made to discover the best methods of bringing certain processes or materials into practical use, and although success has not been attained, yet the way has been so far pointed out that it is hopeless to try and discover an entirely new means of attaining the end. The solution is a matter of degree rather than of principle, and as such does not lend itself to be secured under the provisions of the patent law. Superheating furnishes a case in point. It is generally believed that we are on the verge of a revival of superheating, and that it will be successful. But in years past there was a very determined attempt to use superheated steam. Apparatus was fitted in a large number of instances, particularly on board ship, and after extended trial was abandoned for several reasons. First and foremost, there was the difficulty of finding a lubricant that would not decompose under the influence of very hot steam. The introduction of mineral oils and vaseline has removed that source of failure without any effort on the part of mechanics. Then there was the chance of the superheater becoming incrusted with salt carried over from the boiler with priming water. But salt in boilers is, or should be, a thing of the past, now that evaporators are so common, and thus a second source of failure has disappeared. The other difficulties were chiefly mechanical, and individually were not serious. But, taken in the aggregate, they are fairly formidable, and it is certain that they will take some time and a liberal expenditure of money to entirely overcome. As our columns have shown, attempts are now being made on a practical scale to introduce superheating. The attitude of the profession is one of expectancy; the majority are waiting to appropriate the result of other people's experiments, certain that nothing can be discovered that will furnish grounds for anything but a narrow patent.

It would be possible to adduce examples in many other departments of engineering to show that science languishes and progress is delayed because our predecessors advanced far enough to demonstrate the principles on which we should act, and yet fell short of attaining a commercial success. The last step, which they failed to take, often from not having the requisite material available, is capable of many solutions, and, therefore, seldom can be made the subject of a paying patent. A man may devise half a dozen means of attaining the end, and may fancy that he has closed every avenue to his competitors; but no sooner has he published his plans than alternative methods, of which he never dreamed, start forth like the ghosts at Macbeth's banquet. The man of business acumen waits and lets other people make his experiments for him, relying on his commercial ability to secure a fair share of the results, even if he be a little late in getting a start.

There is, however, one class of men who find it to their interest to make experiments without the hope of direct gain. We refer to professors in technical colleges. They are very favorably circumstanced for making researches, in that a large amount of apparatus is at their disposal, and that they have, to some extent at least, the command of funds for the purpose. Further, they generally have a considerable amount of leisure in the session, while the vacations are far in excess of what is necessary for physical and mental recuperation. They actually get more holiday than the school usher, who has not only to instruct his pupils, but who has also to undertake the formation of their characters and to join in their games. From morn till night, Sunday and week-day, the unfortunate assistant schoolmaster is boy-ridden. He eats with him, he walks with him, he plays with him, and often he sleeps with him. In spite of three intervals of rest per year, he grows narrow and petty, and his society is avoided by men of the world. But the professor is not subject to such contracting influences. He has his lectures to prepare and deliver, and then he is free. If he is to be something more than an animated text-book — a retailer of other men's ideas — he must experiment to furnish himself with original matter, or at any rate with novel illustrations. Further, if he have ambitions beyond the teaching of youths, he must provide for a larger audience than that contained in his class-room. We once heard a civil servant say, "The way to make a reputation in the office is to make a reputation outside it," and that is true of others than those that work for the crown. The engineering professor, until he has made himself a name by original work, is like a figure set up in a fair for every clown, who has learned to chip and file, to have his fling at. He is a mark for the cheap gibe of the man who has never attempted enough to find the depths of his own ignorance. If he would meet the world with a smiling face, untouched by such petty annoyances, he must be sustained by the esteem of the profession. The only way to earn this is by practical work, either in the way of construction or of research. The former avenue is often closed, and even if it be open, it is difficult of entrance to a man who has a permanent engagement which cannot be set aside at will. But at research the professor is on his native heath, and the profession is deep in his debt for much valuable information that has been evolved by a great expenditure of time and thought. Possibly all of it is not immediately applicable in daily life, but that which cannot be used to-day will be available at some future time, as the scope of our knowledges increases. If the total amount of engineering data that has been evolved in scientific colleges and schools could be separated from that obtained from other sources, and presented to us in bulk, we should be amazed to find how great and wide-spreading it is.

The powers of the technical laboratory are, however, distinctly limited. Full-sized experiments are beyond its scope. If no other consideration intervenes, there is always expense to be considered. In spite of the constantly rising fees charged for tuition, educational establishments share in a marked degree in that "eternal want of pence" that troubles the greater part of humanity. The available funds have to be spread over the largest possible area, like boarding-school butter. Investigations on a really large scale can, therefore, not be attempted. There is very little chance of getting these done elsewhere in a systematic manner if, as we have already pointed out, the results cannot be secured to the experimenter under the patent laws. One notable exception, however, is found in this country to this rule. We refer to the researches undertaken by the Institution of Mechanical Engineers. On these there have been spent hundreds — possibly thousands — of pounds, and the results have been freely given to the world. The researches made by the Institution on riveting, on friction, on steam-engine economy, and on alloys, are splendid monuments of the large-mindedness of the council. We know that certain continental societies have carried out similar inquiries, but not, we believe, with the same completeness. It is doubtful if any private person could obtain similar results, since, were his purse ever so deep, he would not be able to command the harmonious and zealous assistance of a number of men of equal ability to those serving on the research committees. He could not offer them such an honorable position as that of being the chosen representatives of a large and influential professional body. He would be obliged to content himself with the services of one man of the first rank, assisted by others of less eminence.

It is strange that such a splendid example should be almost solitary. There is ample scope for other societies to undertake work of this kind without incurring the reproach of being imitators, or of trenching on each others' territory. Next to the necessary work of holding meetings and publishing their transactions, there is no purpose, to which their funds could be applied, so directly valuable to their members, and so remunerative to the profession. It is not necessary that a scientific body should have great accumulated resources. It is prudent, of course, to have something in hand to tide over a few years of bad trade, but that is quite a different matter to accumulating a vast estate. Engineers are not usually men with a long tale of ancestors, whose memory bids their descendants repay the benefits they inherit by making an ample provision for posterity. On the contrary, they have usually made their own way in the world, and are but little indebted to their forefathers. It is contrary to their instincts to make elaborate provision for those who will come after. If the next generation cannot maintain an institution for themselves in average times, they are not likely to derive much benefit from one existing on endowments. If a father have but a moderate sum to bestow on his family, it is far better that he should spend it in setting them up in life with all the advantages of education, rather than he should leave them in comparative ignorance with a limited fortune which is less than a competence.

On all sides we hear the cry for technical education. But if it be good for the youth to have knowledge gathered up for him, and carefully tabulated and codified, surely it is also advantageous for the grown man to have the knotty points of science unravelled for him, so that he may lay out his clients' money with advantage. Economists tell us that cheapening of production increases demand, and this does not apply only to manufactured goods. Scores of pieces of engineering construction are left unattempted because it is known that the cost so often exceeds the estimate. The reason is that the engineer has not the necessary data to guide him, and has largely to guess at his figures. The capitalist naturally declines to pay for the necessary research, since it is not his business to instruct the profession he employs; the private engineer has neither the time nor the money to undertake it; the professor finds the means at his command inadequate for the task. And so matters stand still, waiting till the investing public forget the smart of their last loss, and gather confidence for another plunge. In the meantime the average technical society reads papers, distributes the sessional volumes, and congratulates its members on their wealth. It is a pity it does not do something to enable them to increase their individual incomes, by enabling them to furnish positive categorical assurances to their clients as to the efficiency of their designs and the reliability of their estimates.

It is easy, we know, to raise a host of objections to research work being undertaken by societies. It may be suggested that some departments of the profession will be aided and others will be neglected; that the council will consider the needs of their own practices and neglect that of the rank and file; that reputation will be created at the general expense, and so on. It is so much easier and so much pleasanter to find objections than to undertake the work. But the fact remains that the Institution of Mechanical Engineers has now pursued its experiments for years, on a very extensive and liberal scale, and that no complaints have been made. A large amount of most valuable information has been gained, and there is the prospect that more will be added. But, we ask, why should it be left to one society to furnish funds and time and labor for the entire profession? The possibility and success of these researches have been demonstrated, and it is time that other bodies undertook them as well.—*Engineering.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. XVI. HARTFORD, CONN., AUGUST, 1895. No. 8.

The Lever Safety-Valve.*

GENERAL REMARKS.—We have received so many requests for a rule for calculating the position of the weight on a safety-valve, and the blowing-off pressure when the position of the weight is given, that we have thought it wise to publish such a rule in THE LOCOMOTIVE. It would be easy to give a simple formula for the purpose, but we have considered that the wants of engineers would be best met by explaining the *theory* of the lever-valve, and showing, as clearly as possible, the reason for each step in the calculation.

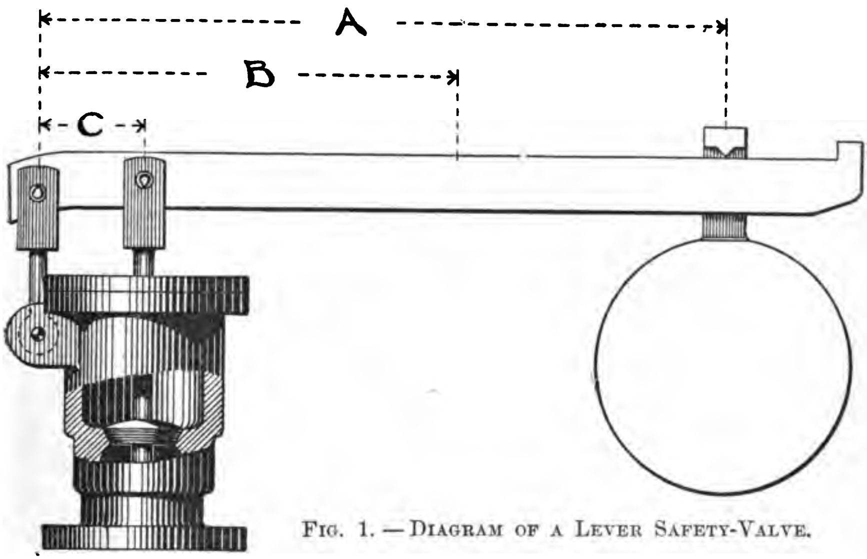

FIG. 1.—DIAGRAM OF A LEVER SAFETY-VALVE.

OBJECT OF THE SAFETY-VALVE.—The object of the safety-valve, as every one knows, is to prevent the pressure in the boiler from rising to a dangerous point, by providing an outlet through which steam can escape when the pressure reaches a certain limit, which is determined by the strength of the boiler, and by the conditions under which it is to work. The simplest device for attaining this end is the "dead-weight" valve, the principle of which is illustrated in Fig. 2. It consists simply of a plate of iron, laid upon a nozzle, and held down by a weight. The calculation of the blowing-off point of such a valve is very simple. In the valve here shown, for example, the steam acts against a circle two inches in diameter. The area of a two-inch circle is $2 \times 2 \times .7854 = 3.14$ sq. in., and the weight tending to hold the cover plate down being 314 lbs., it is evident that the valve will not blow off until the steam pressure reaches 100 lbs. per square inch. Dead-weight valves are used somewhat in England, but they are seldom met with in this country, the commoner form here being that suggested in Fig. 1. It may be well to say that Fig. 1 does not purport to be a good form of valve. We should certainly object to it, if it were placed upon a boiler offered to us for insurance, because no guides are provided for the lever or for the valve stem. These features were intentionally omitted in the engraving, in order that their presence might not draw the attention away from the main points under consideration — the calculation, namely, of the blowing-off pressure and of the position of the weight.

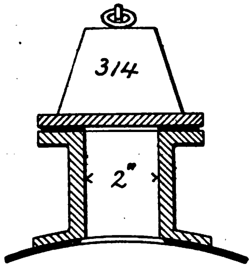

FIG. 2. — A "DEAD WEIGHT" VALVE.

THEORY OF THE LEVER. — In order to be able to perform safety-valve calculations intelligently, one must have a clear idea of the principle of the lever; and it is hoped that such an idea may be had from a study of the illustrations that are presented herewith. These represent a lath, or other

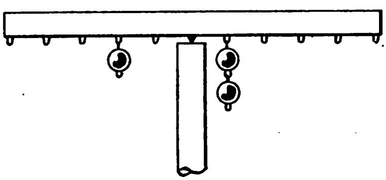
FIG. 3.

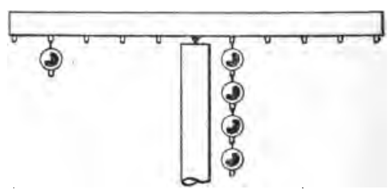
FIG. 4.

light piece of wood, which is balanced upon a knife edge, and into which, on the under side, a number of small staples are driven at equal distances. A number of balls of lead are also supposed to be provided, all exactly alike, and all being

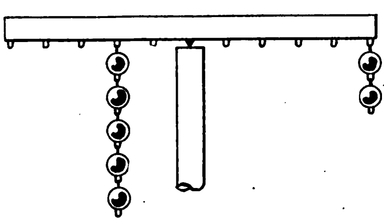
FIG. 5.

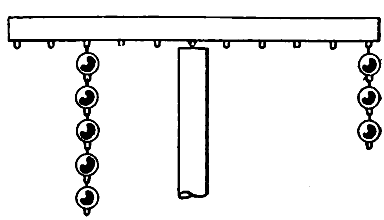
FIG. 6.

furnished with a hook at the top and a staple at the bottom. Two of these weights, when hung upon the first staple, as shown in Fig. 3, will just balance one weight hung upon the second staple, on the other side of the fulcrum. In the same way, four of them, when hung upon the first staple, as shown in Fig. 4, will just balance one hung upon the fourth staple. Five upon the second staple, as shown in Fig. 5, will just balance two upon the fifth staple; and three upon the fifth staple will just balance five upon the third staple, as shown in Fig. 6. It will be seen that in every one of these cases the lath is balanced, *provided* the weight upon one side, when multiplied by its distance from the fulcrum, is equal to the weight upon the other side, multiplied by *its* distance from the fulcrum. This is the principle of Archimedes, and it is used in all calculations relating to the lever. (The reader may find it a profitable exercise to show that the systems shown in Figs. 7 and 8 are balanced. A suggestion is afforded him in Fig. 7, while in Fig. 8 he is left entirely to his own resources. He should find

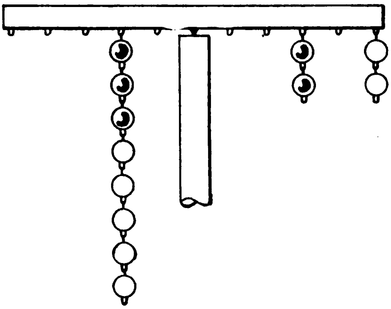

FIG. 7.

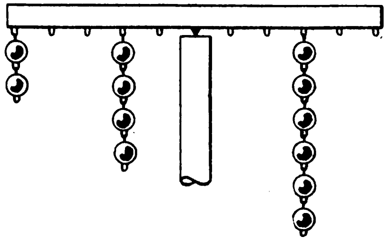

FIG. 8.

no difficulty in either case, however, if he has grasped the fundamental idea which is contained in the illustrations given above.)

APPLICATION TO THE SAFETY-VALVE.— We are now prepared to apply the principle of the lever to the safety-valve, although there is still one point to be cleared up before we can give a complete rule. (The point to which we refer is the influence of the weight *of the arm which carries the ball;* but for the present moment we shall consider this arm to be devoid of weight, and we shall introduce a correction for it later on.) Fig. 9 is a crude representation of a safety-valve, in which the total steam pressure

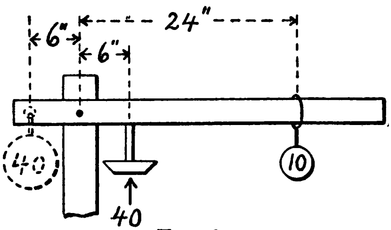

FIG. 9.

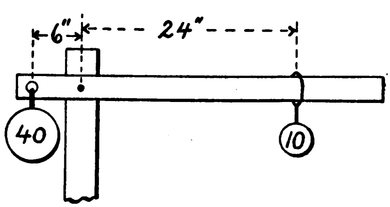

FIG. 10.

against the disk of the valve is supposed to be 40 lbs., and the ball is supposed to weigh 10 pounds. If the valve stem is 6″ from the fulcrum, the ball will have to be 24″ from the fulcrum in order for the valve to blow off at the given pressure — that is, at 40 lbs. This is easily seen, since 6×40 equals 10×24; but if the reader has any doubt about the applicability of Archimedes' rule in this case, he may note that the upward pressure due to the steam can be conceived to be replaced by a 40 lb. weight hung 6″ to the *left* of the fulcrum, as indicated by the dotted circle. The lever will then be equivalent to the one shown in Fig. 10, which is similar in all respects to those shown in Figs. 3 to 8, and to which Archimedes' rule plainly applies. If the blowing-off pressure were not given in Fig. 9, and we were required to find it from the other data there shown, we should reason as follows: When the valve is on the point of blowing off, the upward thrust of the valve-stem is just balanced by the downward tendency of the ball; and, therefore, from Archimedes' principle, 10×24 must equal 6 times the thrust of the valve-stem. But 10×24 equals 240, and hence 240 is 6 times the thrust of the valve-stem, and $240 \div 6$ ($= 40$ lbs.) must be the total pressure exerted on the disk of the valve when it is about to blow off. If the pressure *per square inch* were desired, we should have to divide 40, the total pressure on the valve disk, by the area of the disk in square inches.

THE ARM OF THE VALVE.—In order to take the *weight of the valve-arm* into account, we shall first make a short digression for illustrating the meaning of the expression "center of gravity." Consider, first, the system shown in Fig. 11, where there is one ball on the first staple and one on the fifth. The one ball on the fifth staple is equivalent to five balls on the first one; so that the two balls on the right hand side of the

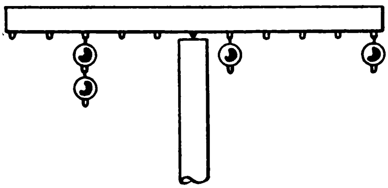

FIG. 11.

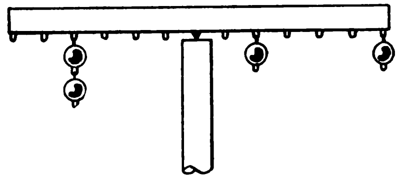

FIG. 12.

fulcrum are equivalent to *six* balls suspended from the *first* staple. They are therefore balanced by the two balls on the third staple; and, in general, if two balls be hung from *any* of the staples, they would be exactly balanced by a pair of balls whose distance from the fulcrum was the average of the distances of the first two. Fig. 12 is a further illustration of this fact. Now, referring to Fig. 13, let us conceive the valve-arm to be without weight, except two small and equal pieces of it, whose distances from the fulcrum are respectively 10″ and 20″. By analogy with the two preceding illustrations, we see that these two little masses would be just balanced by a similar pair of masses, placed 15″ from the fulcrum. In Fig. 14 the same idea is extended to four masses, spaced at equal distances: they would be just balanced by four similar masses, hung at a distance from the fulcrum equal to half the length of the arm. While this kind of reasoning is applicable, strictly speaking, only to the case in which the valve-arm is of equal thickness and width throughout, and has no irregularities whatever, we may, *in practice*, apply it to *all* valve-arms which are *approximately* uniform in cross section; and by extending the conception of Figs. 13 and 14 until the little masses become so numerous as to fill the entire lever, we conclude that a valve-arm of this sort would be balanced by a similar arm suspended (as shown in Fig. 15) at a distance

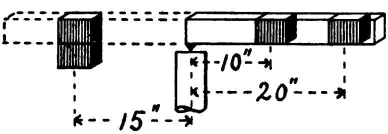

FIG. 13.

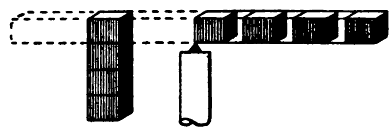

FIG. 14.

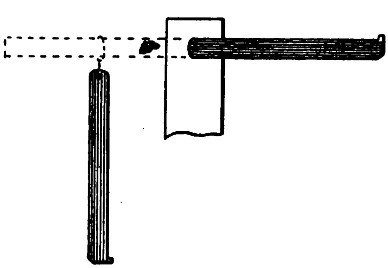

FIG. 15.

from the fulcrum equal to half the length of the arm itself. This amounts to saying that a uniform valve-arm acts the same as it would if its weight were all concentrated *at the middle point of the arm.* The point in a body which possesses this property is called the *center of gravity* of the body. As we have said, the center of gravity of a straight lever may, in practice, be considered to be half way out towards the end of the lever; but if the lever has an appreciable *taper*, the center of gravity will be nearer the fulcrum. The position of the center of gravity can be found, in such cases, by

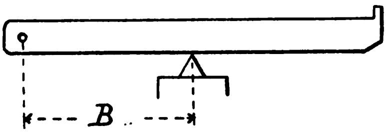

FIG. 16.

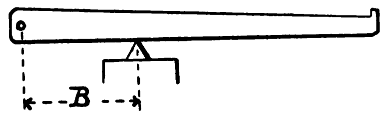

FIG. 17.

calculation; but it is simpler to take the lever out, and balance it across a three-cornered file, as shown in Figs. 16 and 17. It will balance when the center of gravity is just over the edge of the file; and the distance *B* can then be measured directly.

CALCULATION OF THE BLOWING-OFF PRESSURE.—We are now prepared to give a complete example of the calculation of the blowing-point of a safety-valve. Let us take the valve shown in Fig. 18. The arm is 32 inches long and weighs three pounds; the ball weighs 20 pounds and is set 28 inches from the fulcrum; the valve-stem is 4″ from the fulcrum; the valve-disk is 2″ in diameter, and the disk and stem, together, weigh $1\frac{1}{2}$ pounds. It is required to find the blowing-off pressure. In the first place, let us consider the *ball.* It is possible to load the valve-disk directly (just as in the case of Fig. 2) with a weight which shall have precisely the same effect, in preventing the escape of steam, that the actual 20-pound ball has; and our first undertaking will be to find out how big this imaginary "dead weight" would have to be. When we say that it is to be "equivalent" to the 20-pound ball on the lever, we mean that it would just balance that ball, if it were on the *left* side of the fulcrum, instead of on the right; and hence, by Archimedes' principle, 28″ × 20 lbs. must equal 4″ multiplied by the imaginary "dead weight." Now $28 \times 20 = 560$, and $560 \div 4 = 140$. In other words, the 20-pound weight, at a distance of 28″ from the fulcrum, has just the same effect as a 140-pound weight would have, if placed directly upon the valve-disk. In the same way we may investigate the effect of the valve-arm. It weighs 3 pounds, and its center of gravity is 16″ from the fulcrum. A 3-pound weight, 16 inches from the fulcrum, is the same thing as a 12-pound weight, 4 inches from the fulcrum; because $3 \times 16 = 48$, and $12 \times 4 = 48$. Hence the valve-arm is equivalent to a 12-pound weight placed directly upon the valve-disk. The whole lever valve may therefore be regarded as equivalent to a "dead weight" valve loaded with $153\frac{1}{2}$ pounds; for the ball is equivalent to a dead load of 140 pounds, the arm is equivalent to a dead load of 12 pounds, and the valve-disk and stem, taken together, weigh $1\frac{1}{2}$ pounds; and $140 + 12 + 1\frac{1}{2} = 153\frac{1}{2}$. We have therefore found out that the valve will begin to blow when the total pressure of the steam against the valve-disk is 153.5 pounds. The part of the disk which is exposed

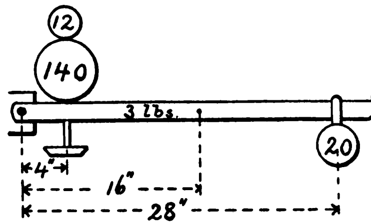

FIG. 18. — FINDING THE BLOWING PRESSURE.

to the steam is 2″ in diameter, and its area is therefore $2 \times 2 \times .7854 = 3.1416$ square inches. The total steam pressure against this area being 153.5 pounds, the pressure against each square inch of it will be

$$153.5 \div 3.1416 = 48.9 \text{ pounds (nearly).}$$

A valve with the dimensions given above will therefore blow off at just a trifle less than 49 pounds per square inch; and the calculation is similar in all cases.

SETTING THE WEIGHT — The method of setting the weight, when the blowing-off pressure is given, is almost precisely the reverse of the calculation given above. As an example, consider the valve shown in Fig. 19. The dimensions are as follows: Diameter of the valve = 4″, length of the lever = 66″, weight of the ball = 50 lbs., weight of the lever = 18 lbs., weight of the valve-disk and stem = 7 lbs., distance of valve-stem from fulcrum = 3″. It is required to set the ball so that the valve shall blow at 100 lbs. per square inch. The calculation is as follows: The area of a 4-inch disk is

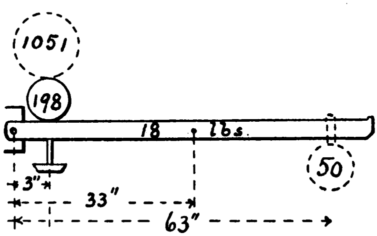

FIG. 19. — SETTING THE BALL.

$$4 \times 4 \times .7854 = 12.56 \text{ sq. in.}$$

and if the steam pressure is 100 lbs. per square inch, the total upward pressure against the valve-disk is $12.56 \times 100 = 1,256$ lbs. If the valve were of the "dead-weight" kind, a load of 1,256 lbs. on the valve-disk would therefore cause it to blow at 100 lbs. per square inch. We therefore have to set the ball at such a place that the action of the ball, the lever, and the direct weight of the valve-disk and stem, shall be equal to a direct load of 1,256 lbs. Now the lever weighs 18 lbs., and its "center of gravity" is (say) 33″ from the fulcrum. It is therefore equivalent to a 198-pound weight laid directly on the valve-disk; for by Archimedes' rule we must have

$$33'' \times 18 \text{ lbs.} = 3'' \times \text{equivalent dead load.}$$

Now $33 \times 18 = 594$, and $594 \div 3 = 198$ lbs., as stated above. In Fig. 19 this dead load (which is equivalent to the weight of the lever itself) is represented by the small weight marked "198"; and the large dotted ball above it (whose weight we are about to find) represents the dead load that is equivalent to the 50-lb. ball out on the lever. The dotted weight, together with the 198-lb. weight, and the weight (7 lbs.) of the disk and stem, must be equal to 1,256 lbs., as we have seen. That is, the dotted weight must be 1,051 lbs.; because

$$1,051 + 198 + 7 = 1,256.$$

The problem has now resolved itself into placing the 50-lb. ball at such a point that it shall be equivalent to a dead load of 1,051 pounds. The valve-stem being 3″ from the fulcrum, Archimedes' rule gives us

$$1,051 \text{ lbs.} \times 3'' = 50 \text{ lbs.} \times \text{distance of ball from fulcrum.}$$

Now $1,051 \times 3 = 3,153$; and $3,153 \div 50 = 63.06$ inches. That is, the ball must be placed 63 inches from the fulcrum, in order that the valve may blow at 100 lbs. per square inch.

Rules. — The processes of calculation which are explained above may now be summarized in the following two rules*:

RULE I. To find the blowing pressure when the position of the ball is given. Multiply the weight of the ball by its distance (A) from the fulcrum, and divide by the distance (C) of the valve-stem from the fulcrum. (This gives the dead-weight that is

* The letters refer to Fig. 1.

equivalent to the *ball.*) Then multiply the weight of the lever by the distance (*B*) of its center of gravity from the fulcrum, and divide by the distance (*C*) of the valve-stem from the fulcrum. (This gives the dead-weight that is equivalent to the *lever.*) Add together the two "dead weights," so calculated, and add in, also, the weight of the valve-disk and stem. (This gives the total weight that is keeping the valve-disk down.) Then divide the sum thus found by the area of the valve-disk, in square inches, and the quotient is the pressure, in pounds per square inch, at which the valve will blow.

RULE II. To set the ball, so that the valve shall blow at a given pressure. Multiply the area of the valve-disk by the blowing-off pressure, expressed in pounds per square inch. (This gives the total effort of the steam to force the valve-disk up.) Subtract, from this total pressure, the weight of the valve and stem. The remainder is the "dead weight" to which the lever and ball, taken together, must be equivalent. Then multiply the weight of the lever by the distance (*B*) of its "center of gravity" from the fulcrum, and divide by the distance (*C*) of the valve-stem from the fulcrum. The result is the "dead weight" to which the *lever* is equivalent; and if this be subtracted from the *total* dead weight, just mentioned, the remainder will be the "dead weight" to which the ball alone must be equivalent. Multiply this remainder by the distance (*C*) of the valve-stem from the fulcrum, and divide the product by the weight of the ball. The quotient is the distance, *A*, that the ball must be placed from the fulcrum, in order that the valve may blow off at the desired pressure.

Cautions. — In applying these rules, two things must be carefully observed. In the first place, the diameter of the valve-disk must be measured at *a b*, in Fig. 20, and *not at c d;* for the steam acts only on the circle whose diameter is *a b*. Again, if the

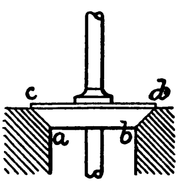

FIG. 20.

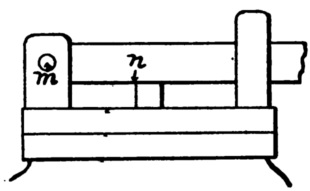

FIG. 21.

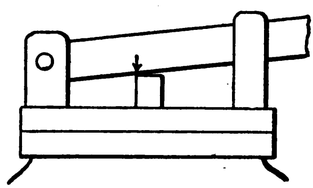

FIG. 22.

valve-stem has a *square top*, as indicated in Figs. 21 and 22, *m n* must be taken as the "distance of the valve-stem from the fulcrum"; because the moment the valve raises in the least degree, the pressure of the stem is all applied to the lever at *n*, as is plainly indicated in Fig. 22.

EXAMPLES. — (1) A valve has a disk 5″ in diameter, and the stem is $3\frac{1}{2}$ inches from the fulcrum. The lever is 60″ long, and as it tapers somewhat, its "center of gravity" was investigated by the method given in Figs. 16 and 17, and found to be 27″ from the fulcrum. The lever weighs 20 pounds, the disk and stem weigh 8 pounds, and the ball weighs 80 pounds and is 54″ from the fulcrum. Find the pressure, per square inch, at which the valve will blow off. (2) A valve is $4\frac{1}{2}$″ in diameter, and the stem is $2\frac{3}{4}$″ from the fulcrum. The lever weighs 15 pounds, is 56″ long, and tapers so little that it may be considered uniform throughout. The valve-disk and stem weigh $6\frac{1}{2}$ pounds. Find where a 75-lb. ball must be placed, in order that the valve may blow off at 80 pounds per square inch.

Answers to these examples will be given next month.

Although the foregoing article is intended simply to explain the *principle* underlying the lever safety-valve, it may be well to touch upon one point concerning the *construction* of such valves. The point we have in mind is this : When the boiler is under steam, it is an easy matter to try the valve, and find out whether it works freely or not. It ought also to be easy to do this, when the boiler is out of use; and in many cases it *is* so. Usually, when the boiler is not under steam, it is sufficient to raise the weight and the lever, and then to try the valve-stem with the thumb and finger ; but some valves are so constructed that the valve-desk is *free from the stem*, and in such cases the fact that the *stem* is free proves nothing whatever, so far as the disk itself is concerned, and the disk must be separately investigated before the valve can be pronounced in good condition. If there is no escape pipe screwed into the valve, the disk can usually be reached from the exhaust side, and its condition noted ; but if such a pipe is provided (as it is, in many cases) the inspector has to examine the disk as well as he can, from the *inside* of the boiler. If the valve does not happen to be secured directly to the nozzle, an examination from the interior of the boiler is not practicable, and then the waste-pipe has to be unscrewed, or the bonnet of the valve taken off, before the disk can be reached. These difficulties, when combined with the fact that there is often no external evidence to show whether the valve is secured to the stem or not, lead us to recommend strongly that valves with separate disks be avoided altogether. They have no very marked advantage over those in which disk and spindle are all in one piece, and as they are likely to deceive one into the belief that all is in good condition, when in reality *the disk may be stuck fast*, we feel justified in condemning their use altogether.

Inspectors' Report.

JUNE, 1895.

During this month our inspectors made 7,961 inspection trips, visited 14,887 boilers, inspected 6,803 both internally and externally, and subjected 667 to hydrostatic pressure. The whole number of defects reported reached 10,967, of which 1,028 were considered dangerous; 72 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	907	59
Cases of incrustation and scale,	1,881	89
Cases of internal grooving,	183	24
Cases of internal corrosion,	712	37
Cases of external corrosion,	795	40
Broken and loose braces and stays,	108	40
Settings defective,	304	17
Furnaces out of shape,	489	20
Fractured plates,	294	65
Burned plates,	251	21
Blistered plates,	254	11
Cases of defective riveting,	1,331	62
Defective heads,	132	9
Serious leakage around tube ends,	1,690	274
Serious leakage at seams,	407	21
Defective water-gauges,	351	39

Nature of Defects.	Whole Number.	Dangerous.
Defective blow-offs,	178	80
Cases of deficiency of water,	20	13
Safety-valves overloaded,	64	13
Safety-valves defective in construction,	90	19
Pressure-gauges defective,	423	50
Boilers without pressure-gauges,	25	25
Unclassified defects,	78	0
Total,	10,967	1,028

Boiler Explosions.

JUNE, 1895.

(144.) — A serious accident happened, on June 2d, in the electric light station at Milford, Mass. Some trouble was experienced on account of a leakage from the safety-valve, and the electrician, George A. Drew, together with the engineer, G. W. Conant, endeavored to repair the valve. While they were at work some part of the valve broke, and the men were hurled violently to the floor by the escaping steam. Mr. Conant received only a sprain, but Mr. Drew was seriously injured. A third employé, who was in the boiler-room at the time, assisted in getting the injured men out, and also drew the fires.

(145.) — George Smith's steam saw-mill, located in the woods about eight miles from Laurel, Del., was annihilated, on June 5th, by the explosion of the boiler. The engineer, sawyer, and two helpers were in the mill at the time, but all of them escaped injury.

(146.) — Fireman Fletcher Sells was instantly killed, on June 10th, by the explosion of a water purifier in the Crystal Ice manufacturing plant on West Broad street, Columbus, Ohio. Oliver Roehm, a brother of Victor Roehm, the manager of the plant, was also terribly scalded. Roehm and Sells were the only men in the boiler-room at the time of the explosion.

(147.) — A boiler exploded, on June 13th, on the Clark farm, near Bradford, Pa., where an oil well was being drilled. Charles Graham, Francis Hane, and John Gonter were standing on the derrick floor at the time, preparing to run the tools in the hole, but they all escaped serious injury. The boiler-house was demolished. The dome of the boiler was hurled 400 feet in one direction, and the rear portion of the shell was thrown 100 feet in another.

(148.) — A boiler exploded, on June 14th, in T. J. Langley's reed and harness factory, Fall River, Mass. Lena H. Horton, Adele Dube, Robert Murray, and Adolph Bellefeuille were killed, and Thomas Berry, Mattie Durocles, Joseph Nuttall, Annie Hurst, Mary Partridge, William Russell, Alice Tremblay, and Ida LePage were injured. Berry was badly burned about the face and crushed about the body ; his skull was also fractured, and he may die. The mill was entirely wrecked, and the property loss will amount to about $20,000.

(149.) — One of the boilers in the water-works at Union City, Tenn., exploded on June 17th with disastrous results. Engineer G. F. Carmon was instantly killed, his body being literally torn to pieces. It is said that another employé (whose name we could not learn) was buried under the ruins. The brick building in which the boilers stood was wholly demolished, and the property loss is estimated at $20,000.

(150.) — A boiler exploded, on June 17th, at the Union Cotton Press, corner of South Peters and Terpsichore streets, New Orleans, La. Clemson Penrose was killed instantly, and Preston Keaghy and A. S. Frankenbush were injured seriously and perhaps fatally. Henry Schneider, Henry Heffler, W. H. Turner, Laura Jones, M. B. Shelby, L. J. Johnson, John Schultz, William Ellis, John Linn, and George Linn were also injured to a greater or lesser extent. We have seen no estimate of the property damage, but it is said to have been large.

(151.) — On June 17th a boiler exploded in Attica, Ind., while a well was being drilled on Charles Peterson's place. William Smith had charge of the engine, and Leonard Stambaugh of the drill. Other persons were sitting about watching the work. Mr. Smith was killed instantly, and Frank Peterson was hurt so badly that he died within twenty minutes. Mr. Stambaugh was horribly scalded, and it is said that he cannot live. Henry Shumar, J. W. Hamar, and Alexander Hamar, were also badly injured, the latter being blown forty feet, over two fences.

(152.) — A boiler exploded in the stamp mill of James M. Lucas, on the Tuerto, Golden, N. M., on June 19th. Mr. Lucas evidently knows little of the tremendous destructive power of steam, for it is reported that he "thinks it was the malicious work of some enemy, and that giant powder was used to accomplish the purpose."

(153.) — A small boiler, located just outside of Brown's restaurant on Market street, Hartford, Conn., exploded on June 19th. The damage was not great, and nobody was injured.

(154.) — A boiler exploded, on June 21st, in Moses' saw-mill, at Spring Hill, near Little Rock, Ark. Joseph Collins and three other men named Brent were killed, and a number of persons were injured.

(155.) — Alonzo H. Crocker's mill, at West Carlyle, near Grand Rapids, Mich., was blown to atoms, on June 22d, by the explosion of a boiler. Martin Skinner and Arthur Barney were killed instantly, and Avery Crocker, the engineer, was fatally injured. One account says that "the bricks of the boiler setting were scattered over a radius of a quarter of a mile."

(156.) — The whaleback steamer *Christopher Columbus* met with a serious accident, on June 23d, while on her way from Milwaukee to Chicago. When directly off Waukegan a fitting on the main steam pipe failed, and the boat was immediately enveloped in a cloud of steam. Albert McConkey was fatally scalded, and cannot live. James Loring, John Hopp, and a man named Steit, were also terribly scalded, and may die. The others injured were as follows: Miss Boxheimer, severely burned about the face and hands; H. H. Darrow, face badly scalded; George W. Keil, badly burned about the face and arms; George W. Keough, terribly scalded about the face and arms; Arnold Kein, slightly scalded on the hand; Frank Rosner, face, breast, and arms badly burned; J. E. Ryan and Nicholas Seter, terribly burned; and Miss Jessie L. Stone, scalded somewhat about the face.

(157.) — On June 23d, while W. F. Kinney, of the J. I. Case Company, was working on the top of a big traction engine back of the warehouse on Eleventh and X streets, Lincoln, Nebraska, the boiler exploded. No damage was done except to the engine. This was almost destroyed. Mr. Kinney very fortunately escaped injury.

(158.) — The boiler in McSurstin's mill, on Credit river, near Shakopee, Minn., exploded on June 25th. Joseph Berres, the engineer, was killed. His body was thrown 175 feet.

(159.) — A boiler exploded, on June 26th, in Hammond & Andrews' mill, near Josselyn, Ga. Mr. Anderson, one of the members of the firm, who was superintending the mill, was killed. William Smith was also killed, and Richard Wright was hurt so badly that at last accounts it was considered impossible for him to live. Henry Covington was also painfully injured, but will recover. The building was destroyed, and some of the machinery was found 500 yards away.

(160.) — A terrific boiler explosion occurred, on June 27th, at the Langhead coke plant of R. L. Martin & Co., near Fairchance, Pa. The office of the company, which was near the boiler-house, was blown to pieces, so that there were not two boards of the building left together. Superintendent Louis McDowell and Bookkeeper Charles Wilson, who were sitting at their desks, were fearfully injured. They were badly bruised and terribly scalded by the steam and hot water. The force of the explosion was such that the big safe in the office was blown several feet from its original position. The noise of the explosion was heard four miles away.

(161.) — A boiler exploded, on June 26th, in Kray & Kelley's paper box factory, at East Weymouth, Mass. W. E. Kray and George Loring were badly scalded, and at last accounts it was considered doubtful if Kray would live.

(162.) — An upright boiler in use at the Crocker paper mill, at Holyoke, Mass., exploded early in the morning of June 28th. Fortunately, nobody was injured.

(163.) — On June 29th a boiler exploded in T. M. Ingraham's mill, near Tyler, Texas. John Spear, fireman, was struck by a flying piece of iron. The entire side of his head was crushed in, and he died in a short time. Thomas Ingraham, Jr., was severely scalded about the back, and a young man whose name we could not learn was also severely scalded on the breast and arms. The engine-house was totally wrecked, and the property loss was large.

(164.) — The boiler of the river steamer *Cornucopia* exploded, on June 30th, near Norfolk, Va., killing Engineer John Kilburn, Fireman Baker, and a deck hand whose name we did not learn.

(165.) — A boiler tube failed, on June 30th, on the steamer *O. E. Lewis*, which runs between Boston and Winthrop, Mass. Fireman John Cunningham was fearfully burned, but his condition is not critical.

An interesting discussion has for some time been going on as to whether repeated vibrations change the molecular structure of iron and steel. Some metallurgists believe that a fracture caused by repeated strains is the result of a change in the structure, and that fibrous wrought-iron is transformed into granular under continuous shocks, while others regard such an opinion as entirely erroneous. Numerous experiments instituted by Badchinger, of Munich, in which bars were submitted to repeated shocks, lead him to the conclusion that strains in iron and steel repeated frequently, millions of times, bring about no change of structure. Reference is also made to certain experiments by which a bar of wrought-iron was made to show, in two fractures only a few inches apart, two distinct kinds of fracture, the one sharply crystalline, the other fibrous, dependent simply upon whether the breaking force was a sharp blow or a slowly applied load. Another authority points out that crystalline fracture is caused by the manner of breaking; that is, transversely broken fibres show granular crystalline faces, but, when pulled apart longitudinally, the same iron will show a fibrous structure. — *New York Sun.*

The Locomotive.

HARTFORD, AUGUST 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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ON page 81 of THE LOCOMOTIVE for June, 1895, in the third line from the bottom of the page, for "February" read "April."

WE have frequent inquiries for books relating to the examination of engineers and firemen. In reply we may say that Emory Edwards' "900 Examination Questions and Answers for Engineers and Firemen" (published by Henry Carey Baird & Co., 810 Walnut street, Philadelphia) is very useful and convenient. Mr. Edwards is an engineer of wide experience in both naval and stationary practice, and his book is a good one.

Award of the Hodgkins Prizes.

Some account of the Hodgkins Fund prizes, for discoveries and essays concerning atmospheric air, was given in THE LOCOMOTIVE for July, 1893. We learn, through the New York *Sun*, that the committee of award has completed its examination of the 218 papers submitted in the competition, from contestants in almost every part of the world.

"The American committee," says the *Sun*, "is composed of the following members: Dr. G. Brown Goode, appointed by the Secretary of the Smithsonian Institution; Assistant Surgeon-General John S. Billings, U. S. A., by the President of the National Academy of Sciences; Prof. M. W. Harrington, by the President of the American Association for the Advancement of Science. A foreign advisory committee, composed of the late Prof. Huxley, M. Janssen of the French Academy of Sciences, and Prof. Wilhelm Von Bezold, Director of the German Meteorological Service, was consulted in connection with the award of the prizes.

"The committee, on August 6, announced its decision as follows:

"First prize of $10,000, for a treatise embodying some new and important discoveries in regard to the nature and properties of atmospheric air, to Lord Rayleigh, of London, and Prof. William Ramsay, of University College, London, for the discovery of argon, a new element of the atmosphere. [An account of this element will be found in THE LOCOMOTIVE for March, 1895.]

"The second prize, of $2,000, was not awarded, owing to the failure of any contestant to comply strictly with the terms of the offer."

This prize was offered "for the most satisfactory essay upon — (*a*) The known properties of atmospheric air considered in their relationship to research in every department of natural science, and the importance of a study of the atmosphere considered in view of these relationships; (*b*) The proper direction of future research in connection with the imperfections of our knowledge of atmospheric air, and of the connection of that knowledge with other sciences." There is a certain haziness about these specifications, and it is not surprising that no one fulfilled them, in the judgment of the committee. Probably very few tried to do so.

"The third prize of $1,000," continues the *Sun*, "was awarded to Dr. Henry de Varigny, of Paris, for the best popular treatise upon atmospheric air, its properties and relationships. Dr. de Varigny's essay is entitled *L'Air et la Vie* (Air and Life).

"A considerable number of papers submitted in competition received honorable mention, coupled in three instances with a silver medal, and in six with a bronze medal. Honorable mention, with silver medals, is awarded to F. A. R. Russell, Esq., Vice-President of the Royal Meteorological Society of Great Britain; to C. L. Madsen, Esq., of Copenhagen, Denmark, and to Mr. A. L. Herrera and Dr. Vergara Lopez of the City of Mexico. Honorable mention, with bronze medal, is awarded to Drs. Franz and Carl Oppenheimer of Berlin; Mr. Alexander McAdie of the United States Weather Bureau; Dr. O. Jesse of Berlin; Mr. Hiram S. Maxim of Kent, England; Dr. A. Loewy of Berlin, and Messrs. D. Deberaux-Dex and Maurice Dibos of Rouen, France. Honorable mention is also awarded to Dr. Charles Smart, U. S. A.; Dr. A. Marcuse of Berlin; Dr. A. Magelssen, Christiania, Norway; Prof. C. Nees, Copenhagen; Dr. F. J. B. Cordeiro, U. S. N.; Prof. F. H. Bigelow, Washington; E. C. C. Daly, Esq., London; Dr. F. Viault, Bordeaux, France; Prof. E. Giesler, Bonn, Germany; Dr. J. B. Cohen, Leeds, England; Prof. Emile Duclaux, Paris; and Dr. Ludwig Eilosvay von Nagy Ilosva, Budapest, Hungary.

"The Hodgkins Fund, from which these prizes were drawn, was established in October, 1891, by Thomas George Hodgkins, of Setauket, N. Y. The donor specified that the income from a part of this fund was to be devoted to the increase and diffusion of more exact knowledge in regard to the nature and properties of atmospheric air in connection with the welfare of man. An announcement of the prizes which were offered was made by the Secretary of the Smithsonian Institution on March 31, 1893. The offer of a prize of this value excited general interest throughout the civilized world, and papers were received from nearly all those who were at all interested in this branch of scientific research.

"It is not likely that the income from this fund will be expended exactly in this way another year, but another method may be adopted, which will accomplish the same purpose."

"Cassier's."

The issue of *Cassier's Magazine* for July, 1895, is remarkable in more ways than one. It is devoted almost exclusively to a study of the problems that arose in attempting to utilize, on a grand scale, the water-power of Niagara Falls. It is, as the publishers have said, "A complete story of the great Niagara power enterprise, comprised in ten articles, with nearly two hundred illustrations, including portraits of the officers and directors of the Cataract Construction Company, the members of the International Niagara Falls Commission, and the engineers under whose supervision the work was carried out."

We are first presented with full-page portraits of the officers and directors of the Cataract Construction Company, eleven in number. Then follows an article on "The Use of the Niagara Water Power," by Francis Lynde Stetson, which is admirably illustrated, and full of suggestive facts. The engraving on page 184 is especially interesting; it represents the distinguished men who constituted the International Niagara Falls Commission. Lord Kelvin is in the center of the group, and about him are Prof. Mascart, Prof. Unwin, Dr. Sellers, and Col. Turrettini. The enormous size of the great lake system drained by the Niagara river is strikingly illustrated by the diagram on page 179. Few persons realize that Lakes Superior, Michigan, Huron, and Ontario are so deep that their beds are, in places, from 200 to 400 feet below the level of the sea.

Following Mr. Stetson's article is a short one by Professor Unwin on "Mechanical Energy and Industrial Progress," and then follows a similar one on "Some Details of the Niagara Tunnel," by Mr. Albert H. Porter, who was resident engineer for the Construction Company, and under whose supervision the preliminary work was done. Mr. George B. Burbank, who was resident consulting engineer, and afterwards chief engineer, then contributes a paper on "The Construction of the Niagara Tunnel, Wheel-Pit, and Canal." Mr. Clemens Herschel, the consulting hydraulic engineer, writes of "Niagara Mill Sites, Water Connections, and Turbines," and Mr. L. B. Stillwell, who supervised the installation of the electric apparatus, contributes "Electric Power Generation at Niagara." We should like to review these articles at length, but space will not allow it. One of the most striking things in Mr. Stillwell's article is his account of the huge nickel-steel field-rings for the dynamos. They are 11 feet 7⅛ inches in diameter, and were forged up from the ingot, without a weld, by the Bethlehem Iron Company.

The remaining articles relating to Niagara are "The Industrial Village of Echota at Niagara," by Mr. John Bogart; "Notable European Water Power Installations," by Col. Theodore Turrettini; "Distribution of the Electrical Energy from Niagara Falls," by S. Dana Greene; and "The Niagara Region in History," by Peter A. Porter.

The publishers of *Cassier's Magazine* are to be congratulated upon the success that they have achieved with their magazine, from the very beginning. Every issue is replete with interesting matter, and profusely illustrated with good engravings. The "Niagara Falls Number," however, surpasses all that they have attempted before; and we take pleasure in expressing our unqualified admiration of it. It shall have a permanent place on our editorial shelf.

Hot Water Boilers and Systems.

The Yorkshire Boiler Insurance and Steam Users' Co., Limited, of Bradford, England, issues the following circular to its patrons, for the care of hot-water heating systems and circulating boilers:

"Constant water supply and free circulation are the essential points to be observed. If any part of the circulating system becomes blocked, expansion of the water or formation of steam by the applied heat will inevitably burst something—probably the boiler. The pipes may become blocked from three causes: (1) Freezing up, (2) furring up, (3) closed stop-valves. Therefore, before lighting the fire see that the whole apparatus (including boiler, feed tanks, and all circulating pipes) is full of water, and the feed and circulation free. In cold weather, and epecially during a frost, never let the fire go out, but bank it up, regulate the heat by dampers, and keep it slumbering at night or when hot water is not required. If there are any stop-valves on the pipes, be most particular to see that they are always open. A dead-weight safety-valve (which may be bought for about ten shillings) is considered essential. It should be fixed upon a short pipe leading direct from the boiler, and suitably guarded. It should be daily tested to see that the valve is free. Any circulating pipes approaching outside air or passing through walls should be well wrapped with felt. All circulating boilers should be opened and cleaned certainly once in each year, and oftener if the feed-water is sedimentary. At the same time the internal condition of the pipes should be ascertained, which may be done either by disconnection at convenient places, or by drilling. Air cocks should be fixed at the highest point of bends and dips, and should be frequently opened to liberate entrapped air. Should snapping or noise occur in the pipes, the circulation is not free. In such a case try the safety-valve and air-cocks and see to the feed; if this course fails, the pipes must be disconnected. In case of doubt, send to the company at once."

An excellent little pamphlet, written several years ago, by William J. Gibson, of Cottage City, Mass., formerly in the postal service, has just come under our notice. It is entitled *Ten Reasons Why We Do Not Get Our Letters*, showing by illustrative anecdotes that the cause in nearly all cases is some fault or bad judgment in the writers; and gives under each reason good advice how the evils are to be remedied. The gross volume of delay and injury caused by all these is so enormous, — four to five million letters going astray every year, — that we think it a public service to reprint his recapitulation, with the sum of his explanations.

1. Mail your own letters. (Others forget and leave them in their pockets, perhaps of suits laid aside. But wives cannot always get away, and husbands will still accumulate odium from forgetting.)

2. Direct them fully and to the right place, city, and State. (Dead Letter Office gets 50,000 a year partially addressed, 6,000 more not addressed at all; men continually put on their own city for the one meant, or the wrong State.)

3. Register important letters. (Clerks may missend them; one careless or sleepy clerk sent a letter with a draft, in spite of its being correctly addressed, to a new prairie town, where it was kept six months before returning to the Dead Letter Office. If registered, it would have been hunted up at once.)

4. Write nothing on the northeast corner. (P. O. stamp may obliterate the name otherwise.)

5. Use government stamped envelopes. (Stamps are forgotten or don't stick; 300,000 such letters are mailed every year.)

6. Have a letter-box at your door. (Letters pushed under the door, or packages left on the step, are always liable to be lost.)

7. Have correspondents write "Transient" on letters sent you while traveling. (Regular residents of that or a similar name get them otherwise, and you may not receive them at all; certainly not if your stay is short.)

8. In strange offices show your written or printed name to the clerk. (If spoken through a partition it is liable to be misunderstood; and one gets his letters much more promptly, because a possible hunt in the wrong place is saved.)

9. In writing to strangers for information of no moment to them, to old, or infirm, or poorly educated people, inclose a stamped *and directed* envelope for replies.)

10. Address letters *distinctly*, in loud penmanship and loud black ink, with the letters clearly formed. (*Three millions* of those which reach the Dead Letter Office every year go there because the writing is too faint or the addresses illegible.—*Travelers Record.*

The Locomotive.

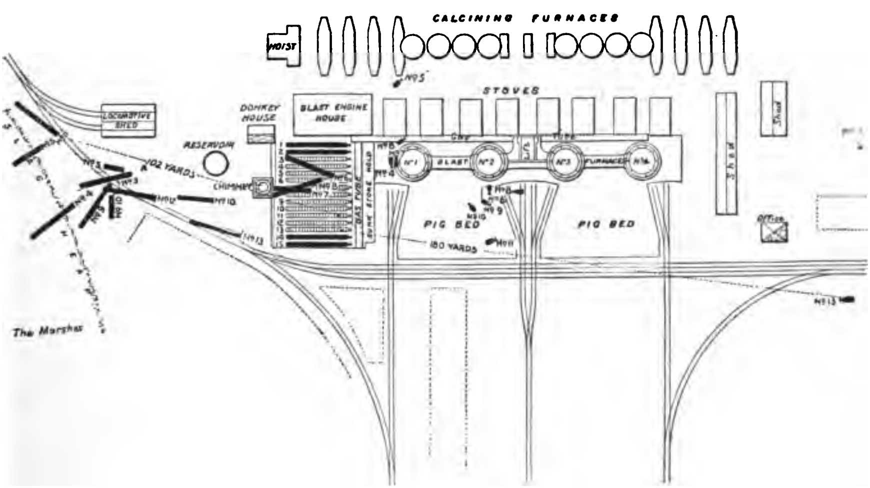
PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES — VOL. XVI. HARTFORD, CONN., SEPTEMBER, 1895. No. 9.

The Redcar Boiler Explosion.

The explosion of a steam boiler has become so common an occurrence, with the increasing use of steam, that in many cases the newspapers dismiss the incident with three or four lines, and often they are not considered sufficiently "newsy" to be mentioned at all. The cases in which two boilers explode simultaneously are not so common, and when *three* or more give way at one time, the occurrence attracts considerable attention.

The greatest explosion on record, so far as the number of boilers involved is con-



THE REDCAR EXPLOSION.

cerned, was the one which occurred at Shamokin, Pa., on the 11th day of last October, in which twenty-seven of them exploded simultaneously. In the celebrated Friedenshütte explosion, which occurred in Upper Silesia, on July 25, 1887, only twenty-two boilers were involved. At Shamokin the number of persons killed was but six, although several others were injured. At Friedenshütte the death list included twelve persons, in addition to which thirty others were injured. So far as we are aware, the cause of the explosion was never unequivocably established in either of these cases. (For an account of the Shamokin explosion see THE LOCOMOTIVE for December, 1894; and for the Friedenshütte explosion see the issue for June, 1888.)

We have now to record another explosion of a similar character, although of lesser magnitude, which occurred at the Warrenby Iron Works, near Redcar, England, on June 14, 1895.* The general facts of the disaster are given by *Engineering* as follows: "The Warrenby Iron Works, near Redcar, were erected some 23 years ago by Messrs. Walker, Maynard & Co., and are still owned by that firm. The steam power was provided by a range of 15 boilers, of the plain cylindrical, egg-ended, externally-fired type, heated by the gases passing off from the blast furnaces. They measured 66 feet in length and 4 ft., 6 in. in diameter, the working pressure being 60 pounds per square inch. Shortly after nine o'clock on the evening of Friday, June 14th, when, fortunately, only about one-fourth of the total number of men usually employed at the works were engaged on night duty, *eleven* of the boilers exploded. The two outer ones at each end of the range did not fail, but remained intact, or nearly so, and pretty much in their original positions. Of the 11 that burst, 10 severed at the third ring seam of rivets from the front end, and the eleventh gave way at the fourth ring seam. The third ring seam, it may here be pointed out, was just over the bridge wall. When the boilers were thus divided, the two sections of each flew in opposite directions, some of them being separated by about 250 yards. The violence of the explosion will be better estimated when it is stated that one of the boilers, or the greater portion of it, was blown upwards of 100 yards forwards, and the back end of another boiler 180 yards backwards, while other fragments were carried to considerable distances and scattered indiscriminately, some of them falling one on the top of another. The brickwork of the settings was reduced to a heap of débris, but the chimney and the blast furnaces escaped injury. It was a fortunate circumstance that the explosion did not occur during the daytime, when a greater number of workmen would have been on the premises. As it was, the results were deplorable; as many as 11 [12] persons were killed, and about 20 others injured. some of them very seriously."

This account, when taken in connection with the outline plan of the works presented herewith, gives a very fair idea of the general circumstances of the explosion. So far as we are aware, no estimate of the property loss has been made, except that the owners of the plant state that the boilers alone were worth about $25,000, and, of course, the total loss would be much greater.

Passing now to the consideration of the *cause* of the explosion, we may note that two distinct and contradictory conclusions were reached by the two authorities who examined this point officially. The coroner's jury found that the explosion was due to the "overheating of one of the boilers through deficiency of water," and that "there had been no negligence, and that everything had been kept up to the correct standard." There is always a large contingent, in any community, which holds tenaciously to the belief that boilers never explode, except from low water; and juries, unless composed of experienced men, are only too ready to accept this solution in any given case, unless there happens to be incontrovertible evidence to the contrary. For this reason we do not consider the finding of the coroner's jury, in the present case, to be particularly valuable. The investigation subsequently carried out by the Board of Trade, in conformity with the Boiler Explosions Act of 1882, is much more instructive. It extended through six days, and the testimony taken is suggestive in many respects. The general conclusion reached by the Commission appears to have been, that the explosion was due to the

* For the data concerning this explosion we are indebted to our esteemed contemporary, *Engineering*.

unequal expansions, and consequent strains, that are likely to occur in boilers of this type. Mr. K. E. K. Gough represented the Board of Trade in the case, and in his opening statement he said that "the 11 boilers, the explosion of which formed the subject of the investigation, were part of a group of 15, all of the plain, cylindrical, externally-fired class, measuring 66 feet in length by 4 feet 6 inches in diameter, the shell being composed of 20 belts of two plates each. The back end of each boiler was composed of six pieces, and the front end of five pieces. A projecting neck was attached to the front end, for the connection of the water gauge. All the shell plates, with the exception of those in No. 15 boiler (which was constructed of steel), were of Robert Heath's single best Staffordshire iron." They were originally ⅜ inch thick, and were united by single riveted lap joints, 11/16" in diameter, and the pitch 1⅞ inches. Boiler No. 1 was made in 1880; Nos. 2 to 7, inclusive, in 1873; Nos. 8 to 14, inclusive, in 1875 or thereabouts; and No. 15 in 1895. "The mountings of each boiler," continued Mr. Gough, "consisted of two safety-valves loaded by lever and weights to a pressure of about 60 pounds per square inch; a glass water-gauge fitted to the end plate of the neck of the boiler, which projected from the brick-work; a low-water alarm, three manholes, and other usual fittings. There was, however, no separate pressure gauge to each boiler, but only one for the whole series [!], in the blast engine-house, and another in the donkey engine-house. The boilers were set in brickwork, and each was supported by five cast-iron brackets connected to the boiler by bolts, the feet of the brackets resting on iron plates on the top of the side walls of the flues. The boilers were fired by the gases from the blast furnaces, suitable openings being provided for the admission of air to promote combustion. The feed-water, which was taken from the town supply, was first heated by exhaust steam, then filtered, and afterwards delivered into the boilers at a temperature of 170° or 180°."

Referring to the events immediately preceding the explosion, Mr. Gough said: "The boilers were in charge of Ayton, the blast engineman. About 3 P.M. on Friday, June 14th, the gas was turned on to No. 4 boiler [which had just been cleaned], and steam was raised about 6 P.M. The stop-valve was opened and all the 15 boilers were then connected. The blast engineman, as No. 5 was next in turn for cleaning, shut off the gases from that boiler about 8.40 P.M., and at the same time closed the valves for admitting air to the furnaces. He went along in front of the boilers, saw that the water was well up in the gauge glasses, and told the attendant to watch the glasses, as the feed was then on. No sound was heard from any of the low-water alarms. He then went into the engine-house and saw that the pressure by the steam gauge was about 58 lbs. Casting was at this time taking place from three of the blast furnaces, and at about 9.20 P.M., when this operation appears to have come to an end, the explosion took place. Boilers No. 3 to 13 (inclusive) all exploded, and, with the exception of No. 13, each separated along the third circumferential seam from the front end. No. 13 separated at the fourth circumferential seam from the front end. No. 14 had its side crushed in, and the two ends of the several boilers were blown in opposite directions and landed in various positions about the works. The contents issued forth amongst the men employed on the blast furnaces, four being killed and 17 others injured, eight of them so seriously that they subsequently died. Inquests were held touching the death of these 12 persons, and verdicts were returned to the effect that 'the explosion was caused by overheating, but how that overheating was caused, there was no evidence to show.'"

So far as the low-water theory of the explosion is concerned, we have to take into consideration the following facts: (1) The low-water alarm did not blow on any one of the eleven boilers that burst; (2) Mr. J. J. Lightfoot, who had worked under Ayton, the blast engineman, for six or seven years, testified that "the low-water alarm whistles worked well"; (3) there was no bulging; (4) the *longitudinal* joints were not started; (5) the only evidence tending to indicate low water was that offered by Mr. William P. Ingham, a consulting engineer, who had drawn up a report for the use of the coroner. Mr. Ingham testified, before the Board of Trade Commission, that "he found evidences of overheating at the first four rings of the front end of No. 13. Externally there was blue oxide, and internally the scale was shelled off in places, and the usual blue or plum color was on the plates." In consideration of the fact that plates overheated through low water are usually *red*, Mr. Ingham's testimony can hardly be regarded as conclusive, and the Commission rightly declined to be governed by it.

Dismissing the low-water theory, let us examine the other possible causes. In the first place, we note that the testimony showed that there was no marked corrosion of the plates, and no considerable amount of scale. It might be thought, perhaps, that the *age* of the boilers was sufficient to account for the explosion; but in the absence of any noticeable signs of deterioration, we do not think that this theory is adequate. The age of a boiler bears no very definite relation to its safety, for boilers often explode when quite new, while others are in good condition after long years of service. (In illustration of this last statement we may mention a case that recently came under our notice in Hammond, Ohio, where a boiler has been in almost continuous service, *day and night*, in a paper mill, since 1856 — a period of thirty-nine years. It was thought best, recently, to take it out and replace it with a new one, of more modern construction; yet, after its removal from the setting, it had every appearance of being good for still longer service. This boiler was well made in the first place, and has been well cared for since.)

Taking the great length of these boilers into account, it must be admitted that the mode of support of the shells, and the location of the feed, are matters of the greatest importance in determining the cause of the explosion. We do not find that the position of the feed-pipe was discussed at all before the Board of Trade Commission. The mode of support was considered, however, but we have not data enough at hand to know whether it was entirely satisfactory or not. Judging from Mr. Gough's opening remarks (quoted above) we should say that there were five pairs of lugs to each boiler, arranged substantially in accordance with the practice in this country for boilers of much shorter length. If this were so, or if the support were in any way *equivalent* to this method, we should consider the design most faulty; for even if the lugs could all be brought to a good bearing at any one time, they would not remain in this condition for any length of time. The yielding of the boiler under varying conditions of temperature and pressure would certainly cause great and serious changes in the distribution of the strains in the shell. These changes would not be likely to affect the longitudinal joints, but if the boiler be considered as a sort of long beam, loaded with a considerable weight of water, and strained also by the internal pressure, it will be apparent that the *girth* joints would be most likely to show distress. If the material of the shell were good, and possessed the proper ductility, the distress at the girth joints would be most likely to show itself through persistent and incurable *leakages;* while if the material were deficient in ductility, the strains (supposing the mode of support to be the prime cause of the explosion) would be almost certain to cause a circumferential fracture along the rivet holes. The testimony taken before the Commission elicited the fact that the plates were made of "best" Staffordshire iron. This name *looks* well from a distance, but if we were in England we should learn that it is only a trade name for a rather poor quality of metal. There is "best" iron, and "best best" iron, and "best best best" iron; and in the present case the material was only just plain "best." In fact, Mr. David Watson, engineer and surveyor to the Board of Trade, said, in his testimony, that "the ductility of the plates was very low, and he doubted if it had ever been much better [*i. e.*, he did not think it likely that the ductility had deteriorated during the lifetime of the boilers]. What was known as 'best' quality," he added, "was really the lowest; and it was certainly too low to be exposed to the flames."

We have given the reasons that would have led us to expect the continued recurrence of fractures along the rivet holes in the girth joints; and the testimony brought out before the commission, on this point, is truly appalling, and confirms our opinion concerning the cause of the explosion, with extraordinary force. In fact, the boilers gave such unmistakable indications of the true state of things, that it is almost incredible that they should have been kept in service. They were, however, and the inevitable disaster came.

The evidence concerning the circumferential fractures did not extend back further than 1888; but there was no need that it should. It is abundant enough as it stands. Briefly stated, the record for the past eight years is as follows: (**1**) In 1888 a fracture was found along a girth joint in No. 6 boiler, and (**2**) another was found in the same boiler in 1889. (**3**) A similar one occurred in No. 7 in February, 1889; (**4**) in July, 1889, there was a rip in No. 8; (**5**) in October, 1889, it became necessary to put a 4-foot patch on the bottom of No. 10; (**6**) in December, 1889, there were rips in Nos. 7 and 14; (**7**) in February, 1891, new plates were required in one of the boilers, from the same cause; (**8**) on March 25, 1891, a fracture occurred along the eighth girth joint of No. 5; (**9**) in October, 1891, three plates had to be replaced in No. 3; (**10**) in 1892, a new bottom plate was required in No. 13; (**11**) in May, 1894, two fractures were discovered along the girth joints of No. 6 boiler, one of them (in the fifth ring) being 3 ft. 8 in. long, and the other (in the seventh ring) 3 ft. 10 in. long. (**12**) In May, 1894, a fracture developed in the sixth ring of No. 9; (**13**) in June, 1894, a fracture 2 ft. 3 in. long was found along a girth joint in No. 4; (**14**) in August, 1894, a similar fracture, 5 feet long, occurred in No. 2; (**15**) in March, 1895, another one was found in No. 4; and (**16**) on June 14, 1895, eleven of the boilers fractured completely around their girth joints, simultaneously, killing twelve persons, injuring about 20 others, and scattering destruction in all directions.

Such is the frightful record of this battery of boilers during the past few years. It shows plainly, that low water had nothing to do with the terrible *finale*, and it indicates, without much doubt, that the true cause was faulty support, combined, perhaps, with an improper arrangement of the feed-pipe. (We cannot speak positively concerning the feed-pipe, because we do not find that it was described by any of the witnesses, nor by Mr. Gough.) The fact that ten of the exploded boilers parted at the same place, indicates that the cause that determined the explosion acted similarly in all of them; and this consideration, alone, would be sufficient, almost, to exclude such irregular and accidental causes as low water, or overheating through accumulation of scale.

In closing this account we wish to say one word in defense of the externally fired boiler. All through the report of the investigation that we have reviewed, we find frequent expressions concerning the "liability of externally fired boilers to seam-rip." Doubtless these expressions were intended to refer to the long, plain cylindrical boilers of the Redcar type; but it is unfortunate that this limitation is left to be *inferred* by the reader. So far as the horizontal *tubular* boiler is concerned, we may say that in our wide experience we have not found this type to be liable to any such defect, when properly designed and constructed.

Inspectors' Report.

JULY, 1895.

During this month our inspectors made 7,952 inspection trips, visited 16,077 boilers, inspected 8,883 both internally and externally, and subjected 750 to hydrostatic pressure. The whole number of defects reported reached 13,983, of which 1,259 were considered dangerous; 95 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,138	58
Cases of incrustation and scale,	2,658	98
Cases of internal grooving,	219	27
Cases of internal corrosion,	1,045	64
Cases of external corrosion,	983	67
Broken and loose braces and stays,	149	40
Settings defective,	443	48
Furnaces out of shape,	525	28
Fractured plates,	353	64
Burned plates,	343	27
Blistered plates,	460	22
Cases of defective riveting,	1,544	91
Defective heads,	351	106
Serious leakage around tube ends,	1,865	234
Serious leakage at seams,	432	17
Defective water gauges,	357	69
Defective blow-offs,	199	61
Cases of deficiency of water,	11	7
Safety-valves overloaded,	81	32
Safety-valves defective in construction,	135	40
Pressure-gauges defective,	573	46
Boilers without pressure-gauges,	11	11
Unclassified defects,	108	2
Total,	13,983	1,259

Boiler Explosions.

JULY, 1895.

(166.) — The boiler at Lowry's mill, on Laurel Run, near Dunbar, Pa., exploded about June 28th. Several men were injured. [This account was received too late for insertion in the proper place. — ED.]

(167.) — The Howard roller mills, at Howard, S. D., were wrecked on July 2d by the explosion of a boiler. The building, which was four stories high, was totally demolished, and O. P. Walker, the engineer, was killed outright. T. C. Gould was fatally injured, W. H. Clark was injured so badly that he died later in the day, and J. P. Lawson died three days later. Robert Debolt also received painful injuries, and C. A. Lawson was badly burned, but will recover. The mill was recently fitted with new machinery throughout, and the loss will be at least $15,000.

(168.)—The boiler at the pumping station of the Yosemite mine, near Salt Lake City, Utah, exploded on July 2d. We have not learned of any fatalities or injuries, but the stoppage of the pump made it necessary to abandon the mine until new boilers could be procured.

(169.)—Alonzo H. Crocker's mill, at West Carlyle, twelve miles south of Grand Rapids, Mich., was blown to atoms on July 2d by the explosion of the boiler. Martin Skinner and Arthur Barney were instantly killed, and Avery Crocker was fatally injured.

(170.)—A boiler exploded at Paterson's tar works, on Front street, Toronto, Ont., on July 2d. The building took fire. No one was injured.

(171.)—On July 4th the boiler of a small pleasure boat on Wooton Lake, near Trinidad, Col., exploded. The boat was a small one, and the boiler was fired up on the Fourth for the first time this season. A trial trip had been made around the lake, and the passengers had just been unloaded at the wharf when the boiler exploded with terrific force, seriously injuring Charles Macomber and a Mexican boy and girl, whose names we could not learn. A number of others were more or less severely scalded and burned by escaping steam. Fortunately, the fragments of the boiler were blown away from the wharf ; otherwise the results would have been appalling. The boat itself was entirely destroyed.

(172.)—A terrible boiler explosion occurred at McManaman's distillery, on the Short-Line railroad, about thirty-three miles from Louisville, Ky., on July 3d. The engineer, whose name could not be ascertained, was terribly scalded about the face and chest, and his right leg was shattered below the knee by a piece of flying iron. It is said that his chance of recovery is small. Mr. McManaman had examined the boiler a few minutes before the accident, and he states that he found everything apparently in good condition.

(173.)—A boiler exploded on July 4th, at Deacon, near Logansport, Ind., in Albert Irvin's saw mill. Wesley Woodruff was badly scalded, but will recover. The front end of the boiler passed through the side of the mill and damaged it to a considerable extent.

(174.)—John Niles's saw-mill, near Salt Lake City, Utah, was destroyed by fire on July 4th, while the owner and all of his men were absent. The boiler also exploded, but we cannot say whether the explosion was the cause of the fire, or the result of it.

(175.)—James Phillips was killed, and Joseph Cropper was seriously and perhaps fatally injured, on July 4th, by the explosion of a traction engine-boiler on Mrs. Jones's farm, in the Neck district, near Cambridge, Md.

(176.)—On July 6th, the boiler of a new steam yacht exploded on Lake Titus, near Malone, N. Y. The owner of the yacht, Mr. E. W. Knowlton, was badly cut about the head by flying pieces of iron, and at last accounts was in a critical condition. W. A. Short, who was also on the yacht at the time, was injured in the leg.

(177.)—A boiler at Schaffer's meat market, Lima, Ohio, exploded July 13th with great force. Mr. Schaffer's daughter was struck by a flying piece of iron and fatally injured, and Mr. J. C. Knapp was horribly scalded. One of the flues of the boiler is supposed to have been defective.

(178.)—A terrific boiler explosion occurred at Henry Wells's farm on Sunfish Creek, about twenty miles from Waverly, Ohio, on July 13th. Taylor Unger, the engineer, was blown nearly two hundred feet and was instantly killed, his skull being frightfully crushed. John Wells, a son of the owner of the place, was also killed. His neck was broken by the shock and he was terribly scalded. George Brant was frightfully scalded, and, although he was still alive at last accounts, his physician pronounced his injuries necessarily fatal. Two laborers, whose names we could not learn, were also badly scalded and burned, but it is believed that they will recover.

(179.) — The boiler of a saw-mill at Mt. Joy, near Portsmouth, Ohio, exploded on July 16th, and completely wrecked the mill. Wm. Long was badly injured.

(180.) — The boiler of a threshing machine exploded, on July 17th, near Tulare, Cal. Engineer Stephen Cornish, who was on the top of the boiler making some repairs, was killed. A man named Mitchell was also killed. Walter Carlton, who was standing directly in front of the fire-box, was fearfully injured. He was burned all over the body, and cannot live. Henry Nofsinger was injured so badly that his recovery is doubtful. John E. Roberts was scalded about the head, and is thought to be injured internally. His brother, Albert Roberts, was painfully burned about the head and neck, but it is believed that he will recover. Amos Johnson was scalded on the face, neck, and chest, and was also badly hurt by a fragment of hot iron. Henry Raymond was seriously scalded about the upper part of his body. William Braden and Frank Mitchell were also painfully scalded.

(181.) — About one o'clock on the morning of July 15th, the boiler of the Niagara Navigation Co.'s magnificent steamer, *Cibola*, exploded at Lewiston, N. Y. Within twenty minutes the steamer was a mass of flames, and shortly afterwards the American Hotel, which was near by, took fire, and the guests had hardly time to escape before the hotel was all ablaze. The steamboat hands, with the exception of third engineer Hammell, escaped by jumping into the river. Mr. Hammell's body was afterward found on the wreck, badly charred. The *Cibola* was valued at $225,000. Nothing was left of it but the iron hull. Mr. Hammell, the dead engineer, was hemmed in by flames near the coal bunkers, and was unable to escape.

(182.) — Missouri Pacific engine No. 235 exploded its boiler in the yards at Sedalia, Mo., on July 21st, as it was being attached to a train. Mr. M. H. Speady, the machinist at the shops, was thrown some distance and was badly scalded about the face, and seriously injured in the back. His condition is critical.

(183.) — On July 25th, a boiler used by a contractor on Third Street, Sheboygan, Wis., exploded, seriously injuring Leonard Verhulst and John Dorse. The boiler was entirely destroyed.

(184.) — Alexander Mousseau of Levaltrie, Ont., was killed by the explosion of a boiler in his creamery on July 26th.

(185.) — On July 26th, a boiler exploded on the Greenwalt ranch, near San Jose, Cal. A heavy iron plate struck George Greenwalt on the back of the head, fracturing his skull and killing him instantly. Horace Granger was badly scalded, and William Greenwalt was fearfully scalded from head to foot. It is probable that William Greenwalt will die, but Granger's injuries are not thought to be fatal.

(186.) — At Peckville, near Scranton, Pa., the boiler of locomotive No 181, on the Ontario & Western railroad, blew up on July 27th. Engineer Myers was instantly killed, and John Fritz was frightfully scalded. Conductor Kelley, and Brakemen Farrell and Murphy, were at the rear end of the train and escaped injury.

Spider Farming.

The following extract from the *Scientific American* may contain a useful suggestion to those housewives who don't know what to do with the eight-legged little creatures that spin webs in the corners of their rooms: —

"Although entomologists have often raised spiders for purposes of scientific observation and investigation, spider raising as a money-making industry is something rather novel. One has only to go four miles from Philadelphia, on the old Lancaster pike, and ask for the farm of Pierre Grantaire to see what can be found nowhere else in this country, and abroad only in a little French village in the Department of the Loire.

"Pierre Grantaire furnishes spiders at so much per hundred for distribution in the wine vaults of merchants and the *nouveaux riches*. His trade is chiefly with the wholesale merchant, who is able to stock a cellar with new, shining, freshly labeled bottles, and in three months see them veiled with filmy cobwebs, so that the effect of twenty years of storage is secured at a small cost. The effect upon a customer can be imagined, and is hardly to be measured in dollars and cents. It is a trifling matter to cover the bins with dust, but to cover them with cobwebs spun from cork to cork, and that drape the neck like delicate lace, the seal of years of slow mellowing, that is a different matter. The walls of Mr. Grantaire's spider house are covered with wire squares from six inches to a foot across, and behind these screens the walls are covered with rough planking. There are cracks between the boards apparently left with design, and their weather-beaten surfaces are dotted with knot holes and splintered crevices. Long tables running the length of the room are covered with small wire frames, wooden boxes, and glass jars. All of these wires in the room are covered with patterns of lace drapery, in the geometrical outlines fashioned by the spider artists. The sunlight streaming through the door shows the room hung with curtains of elfin-woven lacework.

"It is not all kinds of spiders that make webs suitable for the purposes of the wine merchant, and those selected by Mr. Grantaire are species that weave fine large ones of lines and circles. They are the only webs that look artistic in the wine cellar or on the bottles. The spiders that weave these are principally the *Epeira vulgaris* and *Nephila plumipes*.

"When Mr. Grantaire has an order from a wine merchant, he places the spiders in small paper boxes, a pair in a box, and ships them in a crate with many holes for the ingress of air. The price asked, ten dollars a hundred, well repays the wine merchant, who, at an expenditure of forty or fifty dollars, may sell his stock of wine for a thousand or more dollars above what he could have obtained for it before the spiders dressed his bottles in the robes of long ago. Mr. Grantaire has on hand, at a time, ten thousand spiders, old and young, the eggs of some of which, the choicest, he obtains from France.

"When the mother spider wishes to lay her eggs, she makes a small web in a broad crack, then she lays, say, fifty eggs, which she covers with a soft silk cocoon. In two weeks (or longer in winter) the eggs begin to hatch, an operation that takes one or two days. The egg shells crack off in flakes, and the young spiders have a struggle to emerge. Then they begin to grow, and in a week look like spiders. They often moult, and shed their skins like snakes. The brood has to be separated at a tender age, else the members of the family would devour each other until only one was left."

The Locomotive.

HARTFORD, SEPTEMBER 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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WHILE the passenger steamer *Atanan* was landing at the town of Kaneff, Russia, on the river Dnieper, on August 22d, her boiler exploded, injuring thirty persons, some of them fatally. Several others jumped overboard in their efforts to escape from the clouds of steam, and were drowned.

A DISTRESSING accident occurred in the Wyoming Bottling Works, at Wilkesbarre, Pa., on July 28th. A large boiler used there for storing liquid ammonia gave way, and John Gebhardt, Harry Gabriel, and Philip Schmitt were fearfully injured. The air was filled with the fumes of the ammonia, and all the flowers, leaves, grapevines, and other vegetation in the neighborhood were blighted as if from frost. A large tree in front of the works was turned entirely purple, and numerous other trees in the vicinity were affected similarly, though to a lesser degree. We do not know the precise cause of the explosion, but it appears that Gebhardt, noticing a leak or something of the kind, undertook to set up the bolts that held one of the heads, while the boiler was under a pressure of 180 lbs. to the square inch. The head broke, and the contents were discharged.

We have repeatedly referred to the danger of screwing up nuts or bolts under pressure in this way, and the present disaster must be considered as one more object-lesson illustrating the reality of the danger. We wish it might prove a sufficient warning, but we are afraid that thoughtless men will continue in their old habits.

ON August 20th a "hang" fell from the top of a furnace in the Edgar Thompson Steel Works in Pittsburgh, Pa. John Grengo, Joseph Luckai, John Prokopovic, Stephen Havila, John Mika, Joseph Csop, Andrew Drobuah, and Michael Kafinos were killed, and eight other men received burns of such severity that some of them will probably die. It may be well to explain that a "hang" is a mass of slag and other refuse material adhering to the upper part of the blast furnace on the inside; and if it is allowed to remain, it increases in size until it either falls off of its own weight into the melted iron below, or, if its attachment is strong enough, until it entirely chokes the upper part of the furnace and prevents the escape of the gases which are liberated in the reduction of the ore. In the present case the "hang" had been neglected by the top fillers until the mouth of the furnace was nearly or quite choked up. A force of men was then sent up to remove it, and while they were at work it fell into the molten metal underneath, and the accumulated gases rushed out at the top, took fire, and exploded with a deafening roar. The sheet of flame which issued from the top of the furnace struck the men who were scattered about it, and blew them in all directions. One man was thrown over one of the elevators, and his body, striking a car below, was cut in two. Others were burned beyond recognition, and could be identified only by their clothing, or by physical peculiarities.

Riveted Joints.

We are often requested to give an opinion concerning the efficiency of a riveted joint, and our correspondents frequently neglect to give data enough for us to make an intelligent reply. In order to avoid unnecessary correspondence in such cases, we venture to suggest the dimensions that ought to be sent to us.

If the joint is single-riveted, it is sufficient to know the thickness of the plate, the diameter of the rivet (or of the hole into which the rivet is driven), and the pitch of the rivets — that is, the distance from the center of one rivet to the center of the next one. The material of which the plates are made should also be stated, as well as its tensile strength, when this is known.

If the joint is *double*-riveted it is necessary to know the diameter of the rivets (or of the holes), the pitch, or distance between the rivets from center to center (measured parallel to the edge of the sheet), the thickness of the plate, the kind of material of which the plate is made, and its tensile strength, if known. It is not usually necessary to give the distance between the two *rows* of rivets, for it is rare to find a double-riveted joint in which this distance is too small.

If the joint is *triple*-riveted, the data sent us should be similar to those specified above in the case of the double-riveted joint.

If the joint is of the *butt-strap* type, a sketch of it should be enclosed, and the pitch of the rivets (measured parallel to the edge of the plate), the diameter of the rivets (or of the holes), the thickness of the plate, and the thicknesses of the straps, should be marked on the sketch *very plainly*. The material of the plate, and its tensile strength, should also be given.

It is important, in giving the diameter of rivets, to state whether the dimension given is the *diameter of the rivet* before it is driven, or the *diameter of the hole* which the rivet is to fill; and, in general, it should be borne in mind that it is much better to send us *more* data than we would be likely to need, than it is to leave out something that it is really desirable or necessary to know.

Safety-Valve Examples.

Near the end of the article on "The Lever Safety-Valve," in our issue of last month, two numerical examples were given, in order that the engineer might test his understanding of the rules that had been stated. The solution of these examples is here appended:

EXAMPLE I.— In this case the dimensions of the valve and the position of the ball are given, and the blowing pressure is required. This case is provided for by Rule I, and the numerical work is as follows: The ball weighs 80 lbs., and is 54″ from the fulcrum. It is therefore equivalent to a weight of

$$80 \times 54 = 4,320 \text{ lbs.},$$

hung at a distance of *one inch* from the fulcrum. The valve-stem being 3.5 inches from the fulcrum, we have

$$4,320 \div 3.5 = 1,234 \text{ lbs.},$$

which is the dead-weight that is equivalent to the ball. (That is, a weight of 1,234 lbs., applied directly to the valve-disk, would have the same effect as an 80-lb. weight hung 54″ from the fulcrum.) The second operation consists in finding the dead-load that would be equivalent to the lever itself. The center of gravity of the lever being 27″ from the fulcrum, and the weight of the lever being 20 lbs., it is easily seen that the lever is equivalent to a weight of

$$20 \times 27 = 540 \text{ lbs.},$$

hung 1″ from the fulcrum, or to a weight of

$$540 \div 3.5 = 154 \text{ lbs.},$$

placed directly upon the valve-disk. The ball being equivalent to a dead-load of 1,234 lbs., and the lever to a dead-load of 154 lbs., it is plain that the total dead-load, equivalent to the actual ball, lever, and disk, is

$$1{,}234 + 154 + 8 = 1{,}396 \text{ lbs.},$$

the "8" being the weight of the valve-disk and stem (which must be reckoned in, when a very nice calculation is desired). We conclude, therefore, that the valve will begin to blow when the total steam pressure against the disk amounts to 1,396 lbs. Now the disk being 5″ in diameter, its area is

$$5 \times 5 \times .7854 = 19.63 \text{ sq. in.};$$

and the total pressure against this area being 1,396 lbs., it follows that the blowing pressure, expressed in pounds *per square inch* is

$$1{,}396 \text{ lbs.} \div 19.63 \text{ sq. in.} = 71.1 \text{ lbs. per sq. in.},$$

which is the answer sought.

EXAMPLE II. — In this case the blowing point is given in advance, and it is required to find the position of the ball. The diameter of the valve-disk being $4\frac{1}{2}$″, its *area* is

$$4\tfrac{1}{2} \times 4\tfrac{1}{2} \times .7854 = 15.90 \text{ sq. in.}$$

The desired blowing pressure being 80 lbs. per square inch, it follows that the *total* pressure of the steam against the valve disk, at the blowing point, must be

$$15.90 \times 80 = 1{,}272 \text{ lbs.},$$

and this must be just balanced by the weight of the ball, lever, and valve-disk. The valve-disk and stem weigh $6\frac{1}{2}$ lbs., and taking this away from the 1,272 lbs., we have

$$1{,}272 - 6\tfrac{1}{2} = 1{,}265\tfrac{1}{2} \text{ lbs.},$$

which is the "dead weight" to which the *lever and ball*, taken together, must be equivalent. Now the lever being fairly uniform, and 56″ long, we may consider its center of gravity to be at its middle point — that is, 28″ from the fulcrum. The lever weighs 15 lbs., and is therefore equivalent to a weight of

$$28 \times 15 = 420 \text{ lbs.}$$

hung 1″ from the fulcrum, or to a weight of

$$420 \div 2\tfrac{3}{4} = 152.7 \text{ lbs.,*}$$

placed directly upon the valve-disk. Taking this away from the 1,265.5 found above, we have

$$1{,}265.5 - 152.7 = 1{,}112.8 \text{ lbs.},$$

which is the dead load that is equivalent to the ball alone. This dead load applied at a distance of $2\frac{3}{4}$″ from the fulcrum, is equivalent to a weight of

$$1{,}112.8 \times 2\tfrac{3}{4} = 3{,}060.2 \text{ lbs.},$$

hung 1″ from the fulcrum. The problem is therefore reduced to this simple form: To find where a 75-pound weight must be placed, in order that it may be equivalent to a

* In dividing by such a number as $2\frac{3}{4}$, it is convenient to proceed as follows:

$$420 \div 2\tfrac{3}{4} = 420 \div \tfrac{11}{4} = 420 \times \tfrac{4}{11} = \tfrac{1680}{11} = 152.7.$$

weight of 3,060.2 lbs., hung 1″ from the fulcrum. By the principle of Archimedes we have, at once,

$$3{,}060.2 \div 75 = 40.8 \text{ inches};$$

that is, the ball must be hung at a point 40.8 inches from the fulcrum, in order that the valve may blow at 80 lbs. to the square inch.

HEIGHT OF OCEAN WAVES. — Dr. G. Schott, studying the form and height of the waves of the deep sea, found that under a moderate breeze their velocity was 24.6 feet per second, or 16.8 miles an hour, which is about the speed of a modern sailing vessel. As the wind rises the size and speed of the waves increase. In a strong breeze their length rises to 260 feet, and their speed reaches 360 or 364 feet per second. Waves, the period of which is nine seconds, the length 400 or 425 feet, and the speed 28 nautical miles per hour, are produced only in storms. During a southeast storm in the southern Atlantic, Dr. Schott measured waves 690 feet long; and this was not a maximum, for in latitude 28° south, and longitude 39° east, he observed waves of fifteen seconds period which were 1,150 feet long, with a velocity of 78.7 feet per second, or 46½ nautical miles an hour. Dr. Schott does not think that the maximum height of the waves is very great. Some observers have estimated it at 30 or 40 feet in a wind of the force represented by 11 on the Beaufort scale (the highest number of which is 12); and Dr. Schott's maximum is just 32 feet. He believes that in great tempests waves of more than 60 feet are rare, and that even those of 50 feet are exceptional. In the ordinary trade winds the height is five or six feet. The ratio of height to length is about 1 : 33 in a moderate wind, 1 : 18 in a strong wind, and 1 : 17 in a storm; from which it follows that the inclination of the waves is respectively about 6°, 10°, and 11°. The ratio of the height of the waves to the force of the wind varies greatly. — *Popular Science Monthly.*

The Place of Iron in Nature.

Few elements are more abundant in nature than iron, while none is more widely distributed. Its compounds pervade every portion of the earth's crust. Among massive and stratified rocks alike, ferruginous deposits exists on an enormous scale, frequently assuming mountainous dimensions or covering many hundred square miles. The variety of their composition is hardly less remarkable. Thus the useful ores include ferric oxide (Fe_2O_3), known in the crystallized condition as specular iron ore and in the amorphous state as hematite; the magnetic oxide (Fe_3O_4), or magnetite; ferric hydrate (Fe_2O_3+ water), which occurs sparingly in the crystalline form as the mineral gothite ($Fe_2O_3H_2O$), but abounds in the amorphous condition of limonite ($2Fe_2O_3,3H_2O$, but probably a mixture of several hydrates); titaniferous iron, a mixture of ferric oxide with a variable proportion of titanic oxide (TiO_2); ferrous carbonate ($FeCO_3$), or spathic iron ore, with impure varieties known as clay ironstone. To these must be added iron disulphide (FeS_2), of which two crystalline modifications occur, *viz.*, iron pyrites, commonly met with in the form of brass-yellow cubes, and marcasite, much lighter in color, with a radiated structure. Among less abundant but noteworthy compounds may be mentioned magnetic pyrites (Fe_3S_4); copper pyrites (Cu_2S,Fe_2S_3), one of the most abundant ores of that metal; mispickel, or arsenical pyrites (FeSAs), the principal source of arsenic; vivianite, a ferrous phosphate of variable composition, met with in beds in which animal matter has decayed, often of a brilliant blue color.

A few illustrations of the magnitude of some ferruginous deposits may here be quoted. Pilot Knob, in Missouri, a hill seven hundred feet high, consists almost entirely of a single mass of hematite. Near Gellivara, in the north of Sweden, a mountain of magnetite exists, whose dimensions are reported as sixteen thousand feet long, eight thousand feet broad, and two thousand feet high. Beds of magnetite are met with among the Archæan rocks of Canada up to two hundred feet in thickness. In the same region are immense deposits of hematite, titaniferous ore, and iron sulphides. Zirkel describes Erzberg, a mountain in Styria, rising two thousand feet above the neighboring valley, as composed almost exclusively of spathic iron ore.

Besides those ferruginous deposits which from their form or dimensions are entitled to rank as independent rock masses, hosts of smaller aggregations are met with, such as veins, encrusting layers, nodules, and scattered crystals. Thus hematite often occurs in veins traversing crystalline rocks, while layers of ferric hydrate are deposited in their channels by waters containing iron, both above and below the surface. Many of the septarion masses so common in clayey strata consist essentially of clay ironstone. Hematite nodules, often containing fossil remains, abound among some of the carboniferous beds. Masses and single crystals of iron pyrites occur plentifully in some strata, marcasite in others, but what conditions determine the form assumed by the sulphide we do not know. The various "greensands" owe their appellation to the presence of grains of an iron silicate of very variable composition, known as glauconite; deposits of the same mineral are now forming in certain parts of the sea bed. Magnetite may here be mentioned as an essential consituent of basalt and other volcanic rocks, in which it occurs in the form of opaque octahedral crystals.

The most striking evidence of the universal presence of iron in nature is, however, found in the colors imparted by its compounds. Iron has justly been called "the great pigment of nature." Few deposits there are which are not tinged with iron in one chemical form or another. To it are due the brown, yellow, red, green, blue, and creamy tints which in endless variety characterize the vast majority of rocks. Green and blue colorations are produced generally by ferrous compounds, red by ferric anhydride, and yellow and brown tints by ferric hydrates. The presence of other substances, such as carbonaceous matter, largely affects the coloration in many instances.

Probably not more than eight or possibly ten of the elements occur in the earth's crust in larger proportion than iron. The significance of this fact will be appreciated when it is added that ninety-nine out of a hundred parts by weight of the crust are estimated to be composed of some sixteen elements at the most, leaving fifty or more which constitute the remaining one-hundredth part. Nevertheless, in comparison with oxygen, silicon, and aluminum, of which about eighty-five per cent. of the accessible rocks consist, a decidedly low place must be assigned to iron as constituting probably less than one per cent. of the whole, so rapidly does the relative abundance of the elements fall off. About half of the earth's crust is composed of oxygen.

Iron is, as would naturally be expected from the universality of its occurrence elsewhere, one of the elements, some thirty in all, which have been detected in the oceanic waters. Messrs. Thorpe and Morton report the presence of ferrous carbonate to the extent of one part in two hundred thousand in the water of the Irish Sea collected during winter. This proportion, if maintained throughout the ocean, would indicate the existence of more than four billion tons of metallic iron in solution.

In the organic world, again, iron appears to play an indispensable part. It is an essential constituent of the blood, while the production of chlorophyl in plants has been experimentally proved to be, in some way as yet imperfectly understood, dependent on the presence of iron in their nutriment. According to Ehrenberg, some species of diatoms secrete ferric oxide in considerable quantities.

But the existence of iron is not confined to our own planet. The spectroscope reveals its presence in the sun and many of the stars. It is also the chief constituent of meteorites.

Native iron is of very rare occurrence among the terrestrial rocks. Veins are all but unknown. It has most frequently been detected in the form of grains scattered through certain eruptive rocks, such as the gabbros belonging to the volcanic outbursts of Mull and Skye during the tertiary period, and in the basalt of the Giant's Causeway. Nordenskiold has discovered in the island of Disco, off the west coast of Greenland, a number of large masses of iron, one weighing nearly twelve tons; but whether they are of terrestrial origin is doubtful. Similar masses occur in the basalt of the vicinity. The great traveler himself regarded them as memorials of a meteoric fall during the outflowing of the rock in tertiary times; but Daubree has shown that the rock contains microscopic particles of iron, associated with certain other minerals in such a way as to exclude the hypothesis of the conjunction being accidental. He therefore concludes that the iron came from below with the other constituents of the mass.

This subject naturally raises the question, so often asked in view of the high density (about 5.5) of the earth as a whole compared with the average density (say 2.5) of the surface rocks, *viz.*, whether the interior contains large quantities of iron or other uncombined metals. Taking as a guide Sir A. Geikie's list of the sixteen most abundant elements, to wit, O, Si, C, S, H, Cl, P, F, Al, Ca, Mg, K, Na, Fe, Mn, Ba, it is observable that their heaviest combinations with one another barely reach the minimum specific gravity required to account for the earth's density. Whether the enormous pressure, vastly greater than any whose effects we can observe in our laboratories, to which the earth's internal layers are subjected, would serve to compress the materials to the requisite degree is exceedingly doubtful, while it is certain that the high internal temperature of the earth's interior must, to a large extent, counteract the reduction of volume through pressure. It seems most probable, therefore, that extensive deposits of heavy materials of some kind exist in the interior of the earth, and of such none is more likely to abound than iron, considering its high rank as a constituent of the crust.

Meteoric iron is known in masses varying from many tons in weight down to microscopic grains. The latter have been detected in the snows of the Alps and the Arctic region, and caught on board ship in midocean by means of sheets of glass smeared with glycerine and exposed to the wind. Grains of metallic iron abound in the red clay of the Atlantic Ocean, a fact which may be taken as a proof of its slow growth. Meteoric iron is invariably alloyed with metallic nickel. Until recently the natural occurrence of "nickel-iron" (as the alloy is termed, notwithstanding the predominance of the latter element) was unknown except as a constituent of meteorites. Masses of an alloy of the two metals (with other materials) have, however, been lately discovered in the gravel of a stream in Oregon, which differ in some remarkable respects from all meteorites hitherto known. Thus they do not exhibit the peculiar markings, termed "Widmannstatt's figures," when treated with nitric or hydrochloric acid. Josephinite is the name which has been given to the new mineral.

Iron is also found alloyed with platinum. A specimen from Siberia, analyzed by Berzelius, was found to contain 86.50 per cent. of platinum, 8.32 per cent. of iron, together with small quantities of palladium, rhodium, copper, and "gangue." Another sample from South America contained, of platinum 84.30 per cent., of iron 5.31 per cent., of rhodium 3.46 per cent., besides palladium, iridium, osmium, and copper, seven metals in all. — JOHN T. KEMP, in *Knowledge*.

The Locomotive.

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Useless Tubes in Boilers.

Fourteen years ago an article under this heading was published in THE LOCOMOTIVE. It attracted some considerable attention at the time, and as there are still some boiler-makers who do not seem to understand how a tube *can* be useless, we reproduce the article in question, below, and we hope, shortly, to publish some further experiments on the same subject.

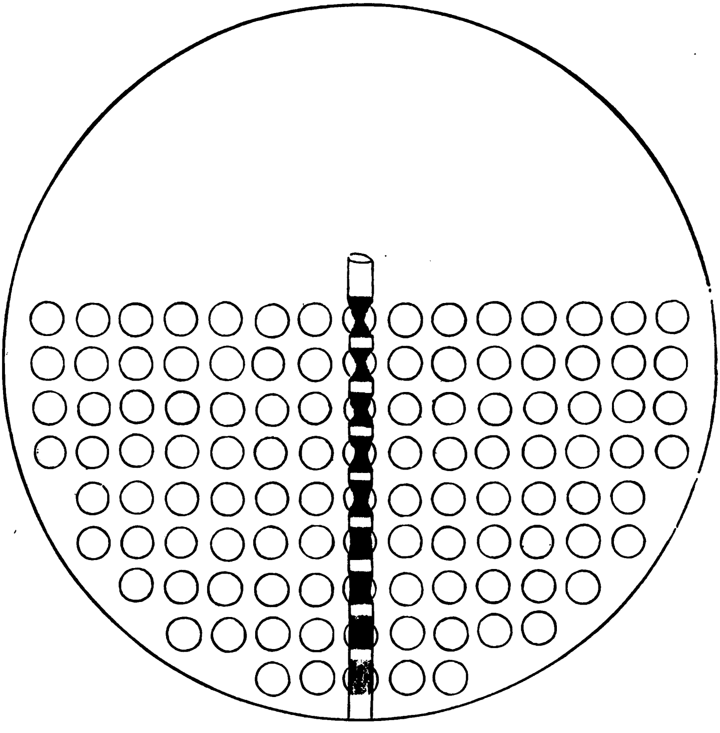

FIG. 1. — ILLUSTRATING THE EFFICIENCY OF TUBES.

In the early history of the horizontal tubular boiler the opinion prevailed that the more tubes that were crowded into a boiler, the greater the efficiency would be. It was not uncommon to find the lower half of a boiler literally packed with 2½-inch tubes. They were put down as near the bottom and the side sheets as the flanging of the tube-head would allow. They were arranged in the boiler on what is known as the "staggered" plan; that is, instead of being placed vertically one over another, they were so arranged that the tubes of one row were placed over the spaces of the row next below, and there were consequently no unobstructed spaces through which the water could circulate. But this was not the greatest difficulty. It is well known that the waters used in boilers generally carry more or less impurities in suspension — mechanical or chemical — and that these are deposited in the process of evaporation. The deposit so formed may consist of the carbonates or sulphates of lime or magnesia, or of argillaceous matter, or of mud. It settles upon the bottom and the tubes of the boilers, and if the cleaning is not frequent and careful, there will be formed, on the bottom and among the tubes, a

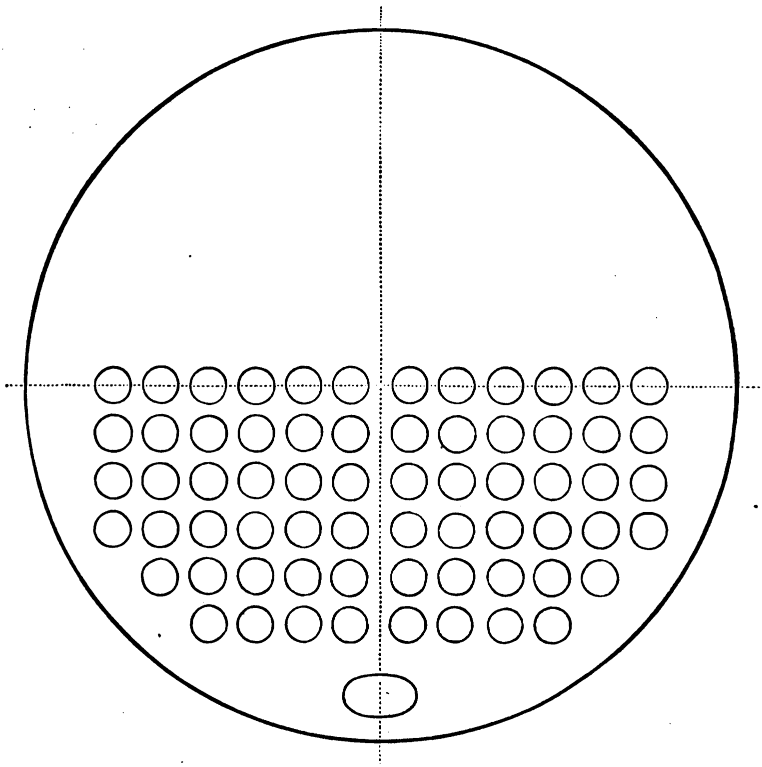

FIG. 2. — A BETTER ARRANGEMENT OF TUBES.

very hard scale, which cannot be removed without taking out the tubes. When this condition of things has come about, the efficiency of the boiler is greatly reduced. The heating surface being covered, more or less, by a substance which is a non-conductor of heat, the heat, in passing over it, is not taken up, and so passes on and is lost.

Matters were materially improved, in the course of time, by the introduction of tubes of larger diameter (3 inches), arranged in vertical and horizontal rows; but the tubes were still carried very near the bottom and sides of the shell, and the difficulty was only partially remedied. A great many boilers are made in this manner to-day, and it is a difficult matter to convince some boiler-makers that it is erroneous. Their argument is, "the more tubes, the more heating surface"; and it must be said that manufacturers, in many instances, have the same views, and in ordering boilers they demand an excessive number of tubes. One object in view in preparing this article is to show that too great a number of tubes does not make the boiler safer, or more efficient. It has been found by experiment that if the two lower rows of tubes in a boiler whose tubes extend down close to the shell are plugged up, the efficiency is not impaired,—we are speaking now of externally fired boilers. By studying the progress of the heated gases as they leave the furnace, it will be seen that they pass over the bridge wall, "lick" the bottom of the boiler its entire length, and then turn upward at the rear end and enter the tubes. The levity of these heated gases carries them mainly to the upper rows of tubes, and only a small portion of them enters the lower tubes. To demonstrate this in a way that will be understood by all (though it may not be regarded as occult enough to satisfy some individuals), a clean piece of soft white pine was placed at the front end of a boiler, nearly in contact with the ends of the center (vertical) row of tubes, as shown in Fig. 1, and was left in that position for several days. When again examined it was found that the end of the stick in contact with the upper tube was burned to a coal, so that it barely held together; at the tube next below it was little less charred, and the effects of the heat decreased more and more towards the bottom, as indicated in the illustration. Against the two lower tubes the wood was only a little discolored, showing that the upper tubes were most effective, while the very lowest were of little account.*

Another fault with the "close" arrangement of tubes is that, besides the trouble from deposit of sediment, there is no body of solid water for the heat to act upon as it leaves the furnace. In our experience we have found great difficulty with this arrangement of tubes, particularly when used with bad water. It gives a greater area of tube surface, but a considerable portion of the surface so gained is useless, and worse than useless, from the fact that the water space is unduly taken up by the superfluous tubes. Fig. 2 shows an arrangement of tubes which is far better. The lower row is well up from the bottom of the boiler, leaving a good solid body of water for the heat from the furnace to act upon. The tubes are kept well away from the shell of the boiler on the sides, no tube being nearer than three inches to the shell, and a space of double width is provided for between the center (vertical) rows of tubes. Good circulation is obtained, and the boiler is much easier cleaned and maintained at its maximum efficiency.

Inspectors' Report.

AUGUST, 1895.

During this month our inspectors made 8,345 inspection trips, visited 16,188 boilers, inspected 6,839 both internally and externally, and subjected 811 to hydrostatic pressure. The whole number of defects reported reached 13,431, of which 1,080 were considered dangerous; 101 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	986	68
Cases of incrustation and scale,	2,218	76
Cases of internal grooving,	204	25
Cases of internal corrosion,	942	59

* Our attention was first directed to this experiment by the Hon. H. B. Bigelow, Governor of Connecticut.

Nature of Defects.	Whole Number.	Dangerous.
Cases of external corrosion,	972	63
Broken and loose braces and stays,	129	34
Settings defective,	339	20
Furnaces out of shape,	455	21
Fractured plates,	370	65
Burned plates,	335	32
Blistered plates,	300	17
Cases of defective riveting,	1,443	74
Defective heads,	184	31
Serious leakage around tube ends,	1,958	186
Serious leakage at seams,	540	39
Defective water-gauges,	497	91
Defective blow-offs,	209	43
Cases of deficiency of water,	27	17
Safety-valves overloaded,	60	21
Safety-valves defective in construction,	129	41
Pressure-gauges defective,	557	47
Boilers without pressure-gauges,	6	6
Unclassified defects,	571	4
Total,	13,431	1,080

Boiler Explosions.

AUGUST, 1895.

(187.) — On August 1st a section of a safety boiler failed at the Union Brewery in Peoria, Ill. The explosion occurred at just six o'clock, as the men were leaving the place. George Gipps and T. W. Slugel, the night engineer, narrowly escaped being scalded to death.

(188.) — A boiler exploded on August 2d in Akers Brothers' mill, situated about seven miles southeast of Kelseyville, Lake County, California. Eleven people were about the mill at the time of the explosion, but only four of them were injured. Joseph Thompson, the engineer, was killed, and Charles Fouts received injuries from which he has since died. John Akers, one of the owners, was blown high in the air, but was fortunate enough to alight in the top of a tree. He was severely injured, but will recover. One of the workmen, whose name we have not learned, was found in a pile of logs about seventy feet from the mill, with both legs broken. The front end of the boiler was blown four hundred feet.

(189.) — The boiler of locomotive No. 181, on the Ontario & Western Railroad. blew up with terrific force on August 3d, on a branch of the road leading to the Blue Ridge breaker at Peckville, Pa. Engineer Herman Myers was instantly killed, and Fireman John Fritz was frightfully scalded, and may die. The engineer was blown many feet into the air, and his body was found sixty yards from the scene of the explosion. Trees near the track were twisted into every conceivable shape, and pieces of the wrecked engine were blown in all directions.

(190.) — A threshing-machine boiler exploded on August 5th at Worley, fifteen miles west of Morgantown, W. Va. Curtis Ammons was instantly killed, and John

Blair, the owner of the machine, was probably fatally injured. John Pitsnaggle and two sons of John Blair were injured, but we could not learn how badly.

(191.) — On August 7th a boiler-head blew out at Tyson's Chrome Works, in Baltimore, Md. Stephen Scofield was severely scalded from head to foot, and at last accounts was in a critical condition.

(192.) — On August 7th a boiler exploded at Demorest, Ga., on the little steamer *Estes*. Some of the excursionists were slightly injured.

(193.) — By the explosion of a boiler at Richard Parham's mill, near Allensville, Ga., on August 8th, George Parham was killed, and William R. Parham, John Parham, and one other man were injured, some of them seriously.

(194.) — The boiler in W. H. Brennan's factory, at Atlantic City, N. J., blew up on August 8th, and several employés narrowly escaped scalding.

(195.) — George W. McMurray was killed on August 9th by the explosion of a boiler which was used for drilling an oil well near Oakdale, Pa. Victor Martin was slightly injured.

(196.) — The boiler of a steam-threshing machine owned by John Frazier exploded on August 9th near Sanford, Ind. Mr. Frazier, who was firing the boiler, was struck by a flying piece of iron, and badly injured. Several other men also received minor injuries.

(197.) — A boiler exploded on August 9th at the pumping-station near the Nickel Plate Railroad tank at Geneva, Ohio. Nobody was injured, but Lyman Cole had a narrow escape from death.

(198.) — A frightful boiler explosion occurred near Monticello, Fla., on August 10th, at P. B. Bird's steam mill and cotton gin. Allen Brooks, Prince Hall, and Amos Gross were killed, and James Reagan, Charles Harrison, Cinderella Johnson, and Nancy Johnson were injured. The buildings were completely wrecked, and the property loss was quite large. It is doubtful if the injured persons recover.

(199.) — On August 12th a boiler exploded in John Hines's mill on Clay Lick, near Mount Sterling, Ky. Hines was blown literally to pieces, parts of his body being found eighty yards from the mill. His son, Butler Hines, was also killed, and the fireman, Frank Smith, was fatally injured. A. J. Downs, one of the workmen, was also injured, and may not recover.

(200.) — A boiler exploded in the Empson canning factory, at Longmont, Col., on August 12th. John Baker, Albert Hanson, George Plain, Frank Printy, and Herbert Vaughn were more or less seriously scalded and bruised.

(201.) — A steam thresher exploded on the farm of Anton LaMott, at Hugo, near Anoka, Minn., on August 12th. Julius Cartier was blown to pieces, and his father, Joseph Cartier, was hit on the head by a flying piece of iron, and injured so badly that he died two days later. —— Merrier was also killed, and J. LaMott was seriously injured. Cartier owned two threshing engines, which had both been inspected and condemned the week before by Deputy Inspector Hanft. Both had serious cracks in the fire sheets. Joseph Cartier was licensed as an engineer, but his son, who was not licensed, was running the boiler at the time of the explosion. Inspector Sutton learned that young Cartier had weighted the safety-valve at three different times in order to get up greater speed, and he estimates that the pressure may have been in the neighborhood of 300 pounds when the boiler gave way.

(202.) — A small boiler in the stair-building shop of H. E. Hubbard, Meriden, Conn., exploded on August 12th. Nobody was injured, and the damage will not exceed a thousand dollars.

(203.) — On August 13th the boiler of a threshing machine belonging to David F. Clark of Clear Lake, S. D., exploded, scalding the fireman, James Altman, so badly that he died on the afternoon of the next day.

(204.) — A traction engine boiler belonging to Mr. James Elmore of Sadler, Texas, exploded on August 13th, killing the engineer, Stephen Miller, and severely scalding John Buchanan. Three other persons were scalded, but none of them seriously.

(205.) — A boiler exploded on August 14th in the Fort Orange Paper Company's mill at Castleton, near Troy, N. Y. One side of the boiler-house was blown out. James Lawton, the watchman, was killed instantly, and his body was found in the ruins. William Johnson, the fireman, was also fatally injured, and died a few hours later. The property loss was about $3,000. It is rumored that the fireman allowed the connection to the water column to become choked up, and that he did not use the gauge cocks, and therefore did not know where the water stood in his boiler. The men who were killed had both been in the employ of the paper company for fifteen years.

(206.) — A boiler on a threshing machine exploded at Oakland, I. T., on August 14th, instantly killing William Craft, Lee Norwood, and Pinkerton Norwood. William Tippet was badly scalded, and cannot recover; C. P. Hamm was bruised and scalded, and will die; James Wilken was also scalded, and is in a critical condition; Claude Howell and T. P. Carter were severely bruised; J. P. Walker was injured painfully, and Mr. Short, the engineer, was badly scalded, and will die. Half a dozen others received burns of a more or less serious character.

(207.) — On August 16th a boiler exploded in a mill at Carrabelle, Fla., tearing out the end of the engine-room, and throwing débris a great distance. Fortunately no one was hurt, although seventy-five workmen were about the building.

(208.) — On August 17th a threshing machine boiler exploded on the McNally farm, six miles southwest of Spencerville, Ohio, and the engineer was fatally scalded.

(209.) — On August 19th a boiler exploded in the basement of the Gumry Hotel, in Denver, Col., converting the rear half of the building instantly into a heap of ruins, and killing twenty-two persons. A number of others were seriously injured — we cannot say precisely how many, because the returns are somewhat unsatisfactory; our list, although incomplete, includes seven names. A daily paper gives the following graphic account of the attempts that were made to rescue those imprisoned in the ruins: "In front of the house there was the sound of glass falling, and people were rushing in night clothes in horror from the doors, and appealing piteously from the windows for help. . . . The firemen, with torch and lantern, entered all parts of the hotel. Out of the pile of brick, wood, and iron below there came feeble moans and piteous cries for help. . . . There still seemed to be no fire. The blaze had been smothered by the falling building, and the firemen devoted their efforts to the work of rescue. And then suddenly the flames broke out, and the workers were driven away, and the voices ceased to cry for help. The great mass was from that moment nothing but a grave. The most that the firemen could do, while the flames shot up fiercely and the smoke drove them back, was to fight fiercely for the life of one poor fellow whose head and shoulders protruded from the burning mass. At times the cries of a babe and the moans of men and women could be heard, but the flames and smoke increased, and finally the voices were all silenced." The explosion was one of the most fearful, so far as the loss of human life is concerned, that we can remember. In many respects it was similar to the explosion which destroyed the Park Central Hotel, in this city, on February 18, 1889, which was illustrated in our issue for March of that year. (The Park Central explosion resulted in twenty-three deaths.) The coroner's jury, after a six-days investigation of the Gumry Hotel disaster, found that it was impossible to fix the responsibility upon any one person, but that the owners, Peter C. Gumry and Owen Griemer, were blamable for allowing their engineer to work sixteen hours out of the twenty-four. They also censured the engineer, Heilmuth Loescher, charging him with negligence; and the city boiler inspector was criticised for not examining the boiler after repairs were made upon it. The total value of the property destroyed was about $75,000.

(210.) — A fearful boiler explosion occurred on August 20th at the New Bedford Machine Shop, New Bedford, Mass. The boiler-house was completely wrecked, and portions of the boiler were thrown 400 or 500 feet. Peter F. Healey was injured so badly that he died a short time afterwards in the hospital. Charles Paddleford was painfully injured. The boiler not only carried away the boiler-house, but also passed through the eighteen-inch stone wall of the main building.

(211.) — A boiler in William Gordon's planing mill at Udora, Ont., exploded on August 20th. Mr. Andrew Thompson was badly injured, and died in about two hours. A small baby (the property of Mr. Wesley Ruttle) received a scalp wound from a fragment of the boiler. The property loss was about $2,000.

(212.) — A threshing-machine boiler exploded on August 23d near Hickson, N. D. Engineer James Conley was badly burned about the head and face, and two of his ribs were broken. John Johnson, the fireman, was fearfully injured about the head. Both men will recover. Several other employés received minor injuries.

(213.) — Monroe Babcock and Annie Hoffman, a nine-year-old girl, were killed on August 26th by the explosion of a threshing-machine boiler at Oowassa, near Eldora, Ill. Three other persons were badly injured, and it is feared that some of them may not live.

(214.) — A boiler exploded on August 29th in the car factory at Warsaw, Ind., killing Quincy Nebruner, the fireman, and James Hoffman, a teamster.

(215.) — A threshing machine boiler blew up at Ardock, near Grafton, N. D., on August 31st. Engineer Patterson was instantly killed.

An inspector writes as follows: "Upon calling at ———'s mill to make an inspection, a short time ago, I found the safety-valve sent away for repairs! A blank flange had been bolted on in its place, and the engineer was going to run without any safety-valve until the old one had been repaired and returned. They were carrying from 60 to 70 lbs., and the boiler was rather old. I told the engineer not to fire up the boiler at *our* risk, as we would not carry it a single hour. He considered the matter a short time, and finally put on another valve before firing up."

The Locomotive.

HARTFORD, OCTOBER 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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THERE always will be pessimists in the midst of us, ready to tell of the retrograde tendencies of the world, and to point out ways in which the civilization of previous centuries was better than that of to-day. The supposed physical degeneracy of the modern man and woman is a favorite theme with these philosophers, and we are frequently invited to look 'way back across the ages to the palmy days of Rome and Athens, and to reflect on the anatomical superiority of the barbarians who "flourished" in those times. Well, we haven't any quarrel with our pessimistic friends; they are apt to be good fellows, though we wish they would give a little more weight to the statistics that show an increase (in recent years, at any rate) in the average duration of human life. Nevertheless, it is refreshing to find a man who is planted as firmly on the other side of the fence as Prof. T. Clifford Allbut appears to be. "I do not hesitate to say," he writes, "that when I look back upon the young men and women of forty and thirty years ago, I am amazed rather at the physical splendor and dashing energy of our young friends of to-day. The world seems to have filled with Apollos and Dianas; cheap food and clothing, improved sanitation, athletics that bring temperance with them, frequent changes of air and scene, and a more scientific regulation of all habits, seem, since my adolescence, to have transformed middle-class youth; and the change is rapidly spreading downward" [*i. e.*, into the lower classes].

President E. F. C. Davis.

We regret to announce the death of Mr. E. F. C. Davis, president of the American Society of Mechanical Engineers. Mr. Davis was born at Chestertown, Md., in 1847, and was graduated from Washington College, Maryland, in 1866. Subsequently he became an apprentice with Brinton & Henderson of Philadelphia, after which he worked for Hoy, Kennedy & Co. of Newcastle, Del. Several years later he went to Pottsville, where he was employed first by the Pottsville Iron & Steel Co., and afterwards by the Colliery Iron Works. In 1878 he became superintendent of the Pottsville shops of the Philadelphia & Reading Coal and Iron Co., and nine years later he became mechanical engineer for the same company. In 1890 he was made general manager of the Richmond Locomotive & Machine Works, which position he held until last spring, when he became general manager of the C. W. Hunt Iron Works of New York city. Mr. Davis was Vice-President of the American Society of Mechanical Engineers from 1891 to 1893, and was President of the Society at the time of his death, on August 6th. He was a man of marked ability, and his personal qualities commanded the respect and esteem of all who were so fortunate as to know him.

We append a transcript from the minutes of the American Society.

"The American Society of Mechanical Engineers desires, through its Council, to spread upon the records of the Society and of its Council a minute expressive of the respect and regard which its members feel and seek to make public, upon the sudden and untimely death, from an accident, of their colleague, Mr. E. F. C. Davis, President of the Society. The formal mould of memorial resolutions in which a corporate body ordinarily records its action seems inadequate for a proper voicing of the spirit which pervades the Council in the presence of the death of one whom its members had known so well, and whom they had learned to admire and to love. His wise and mature judgment, his business and professional knowledge, his conservative yet energetic counsel, and his courteous consideration for others, had made him one from whose administration of the Society's affairs the highest hopes had been entertained. Although with such grief the stranger intermeddleth not, yet the Council would presume to express their heart-felt sympathy with those nearest and dearest to Mr. Davis, upon whom this blow has so crushingly fallen.

"*Resolved,* That copies of this minute be furnished to the engineering journals, with a request that they give it publicity in such a way that it may serve to convey to the profession something of the sorrow and regret with which the American Society of Mechanical Engineers has heard of their loss, in the death of their President."

SOLDERS FOR GLASS. — Mr. Charles Margot finds that an alloy composed of 95 parts of tin and 5 of zinc melts at 200° [C.?], and becomes firmly adherent to glass, and, moreover, is unalterable and possesses a beautiful metallic luster; and, further, that an alloy composed of 90 parts of tin and 10 of aluminum melts at 390° [C.?], becomes strongly soldered to glass, and is possessed of a very stable brilliancy. With these two alloys it is possible to solder glass as easily as it is to solder two pieces of metal. It is possible to operate in two different manners. The two pieces of glass to be soldered can either be heated in a furnace and their surface be rubbed with a rod of the solder, when the alloy as it flows can be evenly distributed with a tampon of paper or a strip of aluminum, or an ordinary soldering iron can be used for melting the solder. In either case, it only remains to unite the two pieces of glass and press them strongly against each other and allow them to cool slowly.— *Scientific American.*

Concerning Thermometers.

Of all the instruments that are used in making physical measurements, there is surely none that seems simpler, at first sight, than the thermometer. The problem of determining the temperature of a body would appear to consist simply in applying the bulb of the thermometer to the proposed body, and noting the scale-reading on the stem, after the mercury has ceased to rise or fall.

When, as in most engineering problems, the temperature of a body is not required with any very great nicety, the operation of determining it is indeed quite as simple as is indicated in the foregoing paragraph; but when it is proposed to determine a temperature *with all the accuracy possible*, the problem is quite a different one. It is seldom necessary to measure a temperature closer than the nearest half-degree, yet it sometimes happens (as, for example, in finding the mechanical equivalent of heat), that *hundredths of a degree* are too large to be neglected; and in such cases the skill of the experimenter is taxed to the utmost, to detect all the possible sources of error, and eliminate them. Some of the difficulties that are met with in refined thermometry are suggested in the following article, and others may be found in the published accounts of the more exact of the various physical researches that have been carried out during the past thirty years or so.*

In the first place, we cannot hope to have any very precise measurement of temperature, until we have a correspondingly precise definition of the quantity to be measured —that is, until we know with great accuracy just what is meant by the word "temperature." We all know, in a general way, what temperature is, and we can usually tell, without much difficulty, which of two bodies is the hotter or the colder; but this general estimation of a temperature, directly by the senses, is a very different thing from the precise measurement of it, to the hundredth of a degree. The first case may be compared to the determination of a distance by roughly *pacing* it, and the second one to *measuring* it with a millimeter scale. We cannot *measure* temperature, in the proper sense of the word, until we have first provided a rigid, unvarying scale, with which the proposed temperature can be compared with great precision.

There is no special difficulty in devising such a scale—in fact, the trouble is that there are so many of them possible, that it is not easy to make the best selection. We might make use of the properties of saturated steam, for example, and define temperature as proportional to the pressure of the steam, or to the square root of that pressure, or to the logarithm of it, or to any other convenient function of it. Or we could vary the same idea by substituting some other kind of saturated vapor for the steam. Or, again, we could make use of the fact that the electrical resistance of a metal changes with the temperature; and we could define temperature as proportional to the change in electrical resistance of a given piece of platinum wire, or any other kind of wire. Many other plans will readily occur to the reader, and it will not be necessary to give further examples. Either of the foregoing methods is well worth serious consideration; and, in fact, they are both actually used, in one form or another, in certain kinds of investigation. It is more usual, however, to make use of the familiar fact that the size of a body changes when the temperature alters. Most substances grow *longer* when they are heated; other substances, such as rubber, and iodide of silver, grow *shorter;* and it is possible to cut bars from certain kinds of crystalline bodies, in such a way that their lengths are quite *independent* of the temperature. We might select some convenient metal, such as iron, or silver, or platinum, and define temperature as proportional to the change in length of a bar of this metal. We might find it hard to put this method into practice, but nevertheless it is logical, and it is certainly theoretically sufficient. In fact, it is in constant use in our own office, for indicating the general temperature of one of the rooms; though we should not care to use it, if any great accuracy were required. In all ordinary cases, it is preferable to make use of the expansibility of some sort of fluid, contained in a transparent envelope. Various kinds of fluid are used for this purpose. The careful scientist uses air, or nitrogen, or hydrogen, for reasons that we cannot here discuss; but it is much more common to use a liquid of some kind, sealed up in a glass tube. A great number of liquids have been tried in this way, and mercury has been found to give the most general satisfaction, although alcohol and glycerine are

* See for example, Rowland, in the *Proceedings of the American Academy of Arts and Sciences* for 1879, and Griffiths, in the *Philosophical Transactions of the Royal Society of London*, volume 184.

also used to some extent; and temperature is usually defined as "proportional to the apparent expansion of a mass of mercury, enclosed in an envelope of glass." *

Suppose, then, that this be accepted as a convenient definition. The next thing to do is to choose a convenient zero-point, from which to reckon the temperatures, and a convenient size of *degrees*. These may be selected in various ways. Thus Fahrenheit, in order to avoid having to deal with temperatures *below* zero (or *negative* temperatures) took, as his zero-point, the coldest temperature known to him. This was obtained by placing the bulb of the instrument in a mixture of snow and salt. The lowest point reached by the mercury was then marked "zero." The size of the degrees could then be chosen arbitrarily, and the stem spaced off into equal lengths; or some other fixed point could be selected, and marked "100°," or "500°," or "1,000°," or any other convenient number, and the stem divided into a corresponding number of equal parts. This second method was the one adopted by Fahrenheit. Making use of the fact that the temperature of the human body is nearly constant, he placed the bulb of an alcohol thermometer in his mouth, and marked the point to which the fluid rose "24°". Later on he decided to call this higher temperature "96", ($96=4\times24$), in order to make the degrees come of more convenient length; and he then divided the stem, between these points, into 96 equal parts.

Such was the original Fahrenheit system. It was good enough for general household use, but entirely too crude for scientific purposes. Neither of the fixed points could be determined with any approach to precision, and hence no two thermometers agreed with each other, when graduated in this way. When it came to be known that the freezing point of water, and the boiling point (under standard conditions of pressure), are exceedingly constant, the plan of graduation was changed. The temperatures of freezing and boiling were not the same on all thermometers, on account of the imperfections in graduation which we have noted above; but they seemed to be about 32° and 212°, respectively, and these values were finally adopted as definitive. A Fahrenheit thermometer is therefore graduated, nowadays, by immersing it first in *freezing* water, and then in the steam rising from *boiling* water; the stem is marked "32°" and "212°" at these respective points, and the intermediate graduation marks, 180 in number (since $212° - 32° = 180°$), are so placed that the volume of the mercury-thread, between any two successive divisions, shall be the same in all parts of the stem. The process is the same with the *Centigrade* thermometer, except that in this case the fixed points are marked "0°" and "100°", and the space between them is divided into 100 parts, instead of 180.

We shall not dwell upon the difficulties that are met with in the actual experimental determination of the fixed points of a thermometer, as these are pretty well covered in most of the standard books on physics. It will be sufficient to say that the boiling-point is the more difficult of the two to determine, because careful attention must be paid to the height of the barometer, as the boiling-point is known to vary with the pressure. It is also found that the temperature of boiling water is not always precisely the same even under a constant pressure. The slight differences that exist appear to depend upon the state of purity of the water, upon the nature of the vessel in which it is contained, and upon the way in which the heat is applied. The *steam* that rises from the water, however, appears to have always the same temperature, provided the pressure be

* The scientist has what he calls an "absolute scale," which does not depend upon the special properties of any particular substance. This scale, which is based upon certain general equations in thermodynamics, is coming more and more into favor; but what we say in the text about the "usual" definition of temperature, is nevertheless quite true.

kept constant; and hence it is customary to immerse the bulb of the thermometer merely in the *steam*, and not in the *water*.

We said that the degree marks on a thermometer must be placed so that the *volume* included between any two consecutive marks shall be the same in all parts of the stem. If the capillary bore of the stem were of *uniform diameter* throughout, this would be the same thing as dividing the stem into degrees of equal *length*; but unfortunately it is found to be impossible to produce a thermometer whose stem shall have a truly cylindrical bore. Usually they are more or less conical, being greater in diameter at one end than at the other; but they are *always* somewhat irregular, and a thermometer is of no use whatever, in accurate scientific work, until it has been "calibrated"; that is, until the irregularity of the bore has been investigated at every point of the stem. It is usual, therefore, to graduate the stem of a delicate thermometer into degrees of *uniform length*, and after the variations of the bore have been investigated, a table of corrections is prepared, which takes all these irregularities into account, and enables one to apply, to any given reading, a correction which will reduce that reading to what it would have been, if the bore of the instrument had been perfectly true. The accurate calibration of a thermometer is quite a delicate operation, and calls for no little skill and patience.

Even after the fixed points have been determined, and the instrument has been calibrated with precision, there are numerous sources of error remaining, some of which are exceedingly perplexing. In the first place, there is what we may call the "personal error" of the instrument. To understand what this is, we must remember that our temperatures are not measured by the simple expansion of *mercury* alone. When the temperature rises the mercury indeed expands, *but so also does the glass vessel that contains it*. The bulb of the thermometer grows larger, too; and it is easily seen that if the mercury did not expand at all, the expansion of the bulb would cause the thread in the stem to travel *downwards*, instead of upwards; and we should have a thermometer in which the higher graduations would be nearest the bulb. In the real instrument both the mercury and the glass expand, and what we actually observe is the *difference* between the two expansions. It is probable that all samples of pure mercury would expand equally, under equal changes of temperature; but it is quite certain that different specimens of glass do not do so, even when they are taken from the same melting. The difference is no doubt due partly to slight differences in composition, and

COMPARISON OF THERMOMETERS.

A	*B*	*C*	*D*	*A*	*B*	*C*	*D*
°	°	°	°	°	°	°	°
212.00	212.00	212.00	212.00	356 00	358.41	358.77	357.93
230.00	230.13	230.16	230.11	374.00	376.52	377.08	376.00
248.00	248.32	248.40	248.25	392.00	394.52	395.33	393.98
266.00	266.58	266.68	266.45	410.00	412.70	413.69	412.00
284.00	284.92	285.06	284.74	428.00	430 88	432.00	430.07
302.00	303.26	303.44	302.99	446.00	449.10	450.43	448.16
320.00	321.66	321.88	321.30	464.00	467.24	468.95	466.45
338.00	340.05	340 32	339.62	482.00	485.15	487.22	484.41

partly to the various unavoidable stresses that exist in the finished thermometer, and which cannot be entirely removed by annealing. Whatever the *causes* of the irregular expansion of glass may be, the *result* is that even when a pair of thermometers agree perfectly at certain temperatures, they are sure to disagree at other temperatures. In order to show the reality of these differences, and to give some idea of their magnitude also, we present a short table, showing the results of a comparison of four mercury in-glass thermometers which were examined by Regnault. These thermometers (distinguished in the table by the letters *A*, *B*, *C*, and *D*) all agreed perfectly at the freezing point and the boiling point, and the readings have all been corrected for imperfections in the bore, so that the differences between them are due simply to the unavoidable "errors of observation," and to what we called, a short time ago, the "personal errors" of the different instruments. The original thermometers were graduated according to the Centigrade scale, but we have reduced all the readings to the Fahrenheit system, as this is likely to be more familiar to our readers. Thermometer *A* is here taken as the standard, but there is no reason for preferring it to *B*, or *C*, or *D*. That is, when *A* read 482.00° under certain conditions, and *C* read 487.22° under the *same* conditions, there was no reason for preferring either of these readings to the other; and yet they differ by over five degrees!

There are several ways to get rid of the "personal error" of a thermometer. One is to investigate the expansion of the glass envelope by a separate series of experiments, planned for this especial purpose. Such experiments are very troublesome and expensive, however, and it is better to merely compare each thermometer with a standard one, which has been elaborately investigated, once for all, and which is carefully preserved for this purpose. Comparisons of this kind are made, for a reasonable charge, at several places. The Johns Hopkins University may be mentioned, in this country, and the Kew observatory in England.

In addition to the various errors due to the structural imperfections of thermometers, there are others which depend upon the way in which they are used. For example, if the bulb of a thermometer is immersed in a hot liquid, and the stem is left out where the temperature is a couple of hundred degrees lower, the mercury in the stem will be cooler than that in the bulb, and the resulting reading will be too low. The error due to this cause will be quite small, but nevertheless it is not absolutely negligible when refined measurements are required. Again, it is no easy thing to make the bulb of a thermometer come to the *exact* temperature of a body in which it is submerged. At first the bulb approaches the desired temperature very rapidly, but soon the thread moves slower and slower, and when the difference has sunk to only a tenth of a degree or so, there is scarcely any discernible motion of the thread. It follows that there is always danger of taking the reading *too soon*. Theoretically, it would take an infinite time for the thermometer to acquire the precise temperature of the liquid in which it is immersed; but in practice, an hour or two may be sufficient to bring the two near enough together to make a reading practicable. This error may be eliminated by taking the mean of two measurements, one made by immersing the thermometer when *warmer* than the liquid to be investigated, and the other by repeating the experiment with the thermometer *cooler* than the liquid.

The effect of variations in the atmospheric pressure are also felt by delicate thermometers. The bulbs of such thermometers are thin, and they yield sensibly under an increase in pressure; so that a given reading will be too high when the barometer stands higher than it did on the day the thermometer was standardized, and too low if the barometer stands lower than it did at that time. According to some authorities this "barometric error" is proportional to the difference between the atmospheric pressure at the time the thermometer is read, and that which prevailed at the time it was standardized; but Professor S. U. Pickering, who is a very careful observer, found that the error does not follow this simple law with accuracy, but that every thermometer has its own peculiar irregularities, which must be separately investigated.

There is also what is known as a "capillary error," in delicate thermometers. The phenomenon which is known to physicists under the name of "surface tension," and which causes small masses of liquid to behave as though their surfaces were little elastic bags or membranes, produces a pressure within the bulb of the thermometer, which is greater, the greater the convexity of the top of the thread in the thermometer stem. If the convexity of this surface were always the same, the capillary error could be neglected; but as a matter of fact the top of the thread is flatter when the thermometer is falling, and rounder when it is rising; it is also flatter where the bore of the stem happens to be a little larger than it ought to be, and rounder where the bore is a little too small. These irregular capillary effects are of considerable magnitude when the bore of the thermometer is made very fine (with the object of attaining greater sensitiveness); and they are often sufficient to cause the mercury to move past certain parts of the graduation by jerks and jumps, rather than with the regular, uniform expansion that is essential to accuracy. Such thermometers are extremely vexatious, and their readings are always regarded with suspicion.

One of the most troublesome things about a delicate thermometer is the fact that when it is used to measure a proposed temperature its reading is not entirely determinate, unless special precautions are taken; that is, the temperature that it indicates will depend, not simply upon the *actual* temperature that is to be measured, *but also upon the recent history of the thermometer itself.* This is due to the fact that when glass is subjected to an alteration in density, or to a new distribution of strains (as it is when its temperature is changed), it does not immediately go back to its original condition. Some observations made by Rowland in connection with this point may be of interest. Taking a thermometer which had lain in its case for four months or so, at a temperature of about 70° to 75° Fah., he found that when immersed in freezing water it read precisely 32.00° (after the various known corrections had been applied). He then heated it to 86° Fah. for a short time, and found that after this treatment it indicated the temperature of freezing water to be 31.97°. It was next heated to 104.9°, after which the reading, in freezing water, was 31.94°. Similar experiments were tried at other temperatures, up to 212°. After being heated to 194°, for example, the reading in freezing water was 31.58°. After a short boiling (at 212°) the reading was 31.44°; and after a more prolonged boiling it was 31.38°. The experiments were then ended, and the thermometer was examined, from time to time, to see how long it would be before its reading was again correct. The reading, shortly after the boiling, was 31.38°, as we have already said. Nine days later it was 31.80°; and after a month it was 31.96°. (Much larger errors are introduced when the thermometer has been used for *high* temperatures; in some cases thermometers have been known to read as high as 70° or so, when placed in freezing water after having been used for a considerable time at temperatures near the boiling point of mercury.) Rowland concluded, from his experiments, that after a delicate thermometer had been employed for measuring a temperature of not more than 100° Fah. or so, it would be in condition for use again in about a week.

There is one more source of error to which we desire to refer, and that is, the gradual rise of the freezing point, which goes on progressively as the thermometer grows older. Joule observed one of his thermometers for many years, and found the results given in the following table. The second and fourth columns give the readings that he obtained from the thermometer upon immersing it in freezing water on the dates given in the first and third columns. This progressive change in the freezing-point (as read by the thermometer) appears to be due to the shrinkage of the bulb of

Date.	Reading.	Date.	Reading.
April, 1844, ...	32°.00	March, 1867, . . .	32°.91
February, 1846, . . .	32 .42	February, 1870, . . .	32 .93
January, 1848, . . .	32 .51	February, 1873, . . .	32 .94
April, 1848, ...	32 .53	January, 1877, . . .	32 .98
February, 1853, . . .	32 .68	November, 1879, . .	32 .99
April, 1856, ...	32 .73	December, 1892, . .	33 .02
December, 1860, . . .	32 .85		

the thermometer. It is somewhat rapid when the instrument is quite new, and hence it is customary to let delicate thermometers lie in their cases for six months or so, after they are made, before attempting to graduate them.

Concerning Long Cylindrical Boilers.

To the Editor of THE LOCOMOTIVE, *Sir:*

I have read the account of the Redcar boiler explosion, in your issue for September, and I believe that this one and that at Shamokin resulted from the same cause. I often wondered why so many of the boilers exploded simultaneously, and I now firmly believe that the peculiar construction of the boilers was the cause of the trouble. Long cylindrical boilers are hard to hang up evenly, and hence the girth seams are likely to be strained to a great extent. At the blast furnaces of the Milwaukee Iron Company (now the Illinois Steel Company) they used to have ten plain cylindrical boilers, 60 ft. long and 42 in. in diameter, each of which was hung from five cast-iron arches straddling the boiler and resting upon the side walls. When the boilers were cold and the hangers were adjusted to carry the load evenly, the boilers were certainly well hung, but as soon as the firing began, the ends of every one of them lifted up from two to three inches, leaving the entire boiler and its heavy contents (including the brick covering) hanging on the middle arch. The boilers were torn off their seats at the ends, lifting small pieces of wall with them; and the girth seams near the middle were severely strained. But as the boilers were mostly in use, it was considered best to screw up the end hangers to help to carry the weight. Now, any variation of steam pressure, due to greater or lesser firing, or any other cause, would shape the curve of the boiler differently, and when the boiler was cooled down for cleaning, the middle hangers would get loose so that the boiler then rested upon its ends, straining the end girths the most. Many of those kind of boilers are so arranged that they are resting more on the ends when hot, and *only* on the ends when cold. As all boilers in a nest are treated about alike with uneven firing, and with cooling down, and as the iron and steel in all is about alike, and also the workmanship, it stands to reason that they all are weakened about in the same degree. You will remember that the Shamokin boilers also broke in two, and that their ends flew in opposite directions. I believe no boiler ought to have more than two hangers or lugs on each side. Mr. Geo. Hackney, master mechanic of the Milwaukee Iron Company, about twenty-two years ago saw the danger and had all the boilers cut in two and connected by copper goose necks, each half being hung to two arches, and this certainly was a good step.

R. BIRKHOLZ, M.E.,
Pabst Brewing Co.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

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On the Support of Long Cylindrical Boilers.

In the September issue of THE LOCOMOTIVE we gave some account of the great boiler explosion which occurred at Redcar, England, on June 14, 1895, and in the course of the article we attributed the explosion chiefly to the strains produced in the shells of the boilers *through faulty methods of support.* The support of long cylindrical boilers is a problem of the first importance, and as we have said but little on this subject for some years past, it may be well to touch upon it again.

In the first place, it is necessary to understand the trying conditions under which these boilers are run in the rolling mills and iron works in which they most frequently occur. They are run day and night, and there are great and violent changes in the work required of them, with correspondingly sudden variations of pressure. The engines may be running light, for example, and using little or no steam, when suddenly

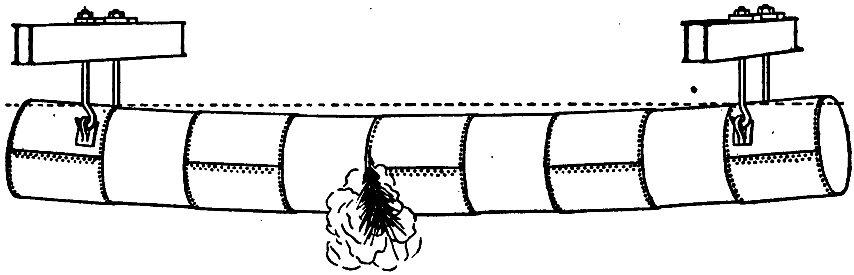


FIG. 1.— ILLUSTRATING THE SAG OF LONG BOILERS, WHEN IMPROPERLY SUPPORTED.

a heavy bloom is seized by the rolls and the machinery comes almost to a standstill — the engine-valves being then wide open, and the draft of steam tremendous. The pressure in the boiler may fall materially while this heavy work is going on, but it will be only a few moments before the rolls are running light again, with the steam pressure up almost to the blowing-off point.

The extraordinary *length* of these rolling-mill boilers would be quite sufficient to make the problem of support a serious one, even if the work required of them were fairly uniform. They are frequently fifty feet long, and those which exploded at Redcar were no less than *sixty-six* feet long. Such boilers, even when exposed merely to the conditions of ordinary service, would be expected to change their shape sensibly under such variations of pressure and temperature as might occur; and in rolling-mill practice, where these variations are far greater, the changes of form, and the corresponding variations in the distribution of stress in the shell of the boiler, are far more serious. The long rolling-mill boilers are heated by the waste gases from blast-furnaces or cupolas, and the conditions under which they are run are very variable. At times the combustion chamber under the boilers will be fairly cool, — hardly hotter than the boilers themselves, — while at other times great sheets of flame sweep along the shell for its entire length.

Rolling-mill boilers have frequently been supported rigidly at three points — one at each end and one in the middle, — as shown at *A*, *B*, and *C*, in Fig. 2. This might seem to be a proper disposition of the supports, but experience shows it to be faulty and dangerous. The hot gases, striking against the lower shell plates, raise the temperature of the bottom of the boiler so that it becomes sensibly hotter than the top. The bottom of the boiler therefore expands and becomes longer than the top, and the boiler becomes curved in the manner illustrated, on an exaggerated scale, in Fig. 1. The entire load is

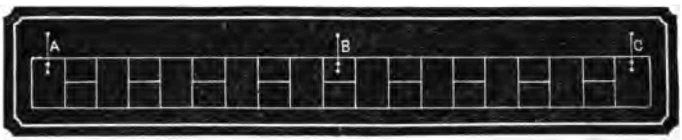
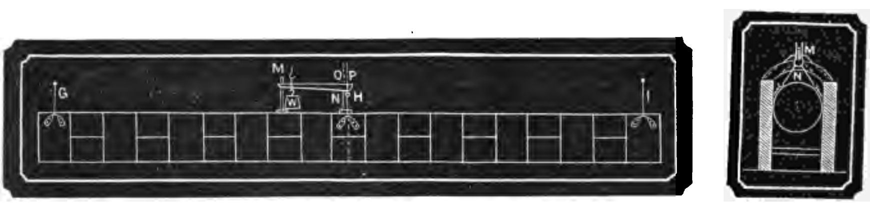


FIG. 2.— A LONG BOILER WITH THREE SUPPORTS.

then thrown on the middle support, and this, unable to carry such a heavy burden, sometimes breaks away, and the boiler falls until the end supports are again taut. The shock so produced, together with the strains already existing in the shell, on account of the pressure, often proves too great to be resisted, and the boiler parts at a girth joint, and great destruction follows. (Fig. 1 represents a boiler which is in the act of parting around one of its girth joints, in consequence of the great strain thrown upon the joint by the weight of the boiler and its contents, together with the steam pressure.)

In designing a mode of support that shall be safe and effective, the point to be borne in mind is the necessity of providing for the possible motion of the boiler, under the varying conditions of service. The supports must be strong and substantial, and



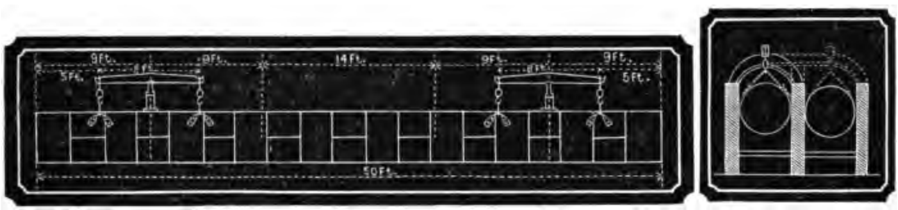
FIGS. 3 and 4.— METHOD OF SUPPORT BY MEANS OF A COUNTERPOISE.

yet they must not be too rigid and unyielding. It is also necessary to see that the boiler is not bound up tightly in the brick-work; for if it is, fractures are very likely to occur.

The necessary pliability of the supports may be attained in various ways, and some of the methods that have been proposed are quite elaborate. We shall suggest only two of the simpler modes that have been tried and found to be satisfactory. A plan that has worked well in practice is shown in Figs. 3 and 4. Here there are three supports as before, but the middle one is not rigid, its hangers being attached to a lever which is provided with a weight, *W*, proportioned so as to counterbalance the weight of the boiler. To adjust this apparatus properly, the weight of the boiler and its contents must be known. As an example, let us suppose the boiler to be 50 feet long, and 48 inches in diameter. Allowing for laps, rivets, heads, and the contained water, the whole would weigh about 30,000 pounds. The center support would carry half the weight of the boiler, or 15,000 pounds.* If the lever be so proportioned that the fulcrum is 3 inches from the end *H* (where the hanger is attached), and 60 inches from the weight *W*, then, by the principle of the lever, we have

$$3'' \times 15{,}000 \text{ lbs.} = 60'' \times (\text{the weight } W).$$

Now 3 × 15,000 = 45,000, and 45,000 ÷ 60 = 750 lbs., which is the weight that must be hung at *W* to balance the load that comes on the hanger *H*. (Of course in practice there are two hangers at *H*, one on each side of the boiler. In the calculation here given the two are supposed to be secured to the same lever, as indicated in Fig. 4.) It is well to make the weight, *W*, in *sections*, so that it can be handled conveniently. The lever should run in guides that are placed *outside* of the weight *W*, as shown in Fig. 3; and there should be a seat for the end of the lever to rest on when the boiler is empty or not under steam.



FIGS. 5 and 6. — METHOD OF SUPPORT BY MEANS OF EQUALIZING LEVERS.

The other mode of support, referred to above, is shown in Figs. 5 and 6. In this method the weight of the boiler is supported by four pairs of hangers, which are secured to equalizing beams as suggested in Fig. 5. To illustrate the method with some degree of definiteness, we have assumed the boiler to be 50 feet long. The first support is then 5 feet from the end of the boiler, and the beam, from the outer hanger to the inner one, is 8 feet long. (It might be 10 feet long with advantage.)

There are many other ways of supporting long boilers, and in deciding on the adoption of any one of them the important point to bear in mind is whether or not the proposed system has sufficient pliability to allow the boiler to change its size or shape slightly, without interfering with the equal distribution of the load on all of the supports.

Inspectors' Report.

SEPTEMBER, 1895.

During this month our inspectors made 7,937 inspection trips, visited 16,072 boilers, inspected 6,391 both internally and externally, and subjected 845 to hydrostatic pressure. The whole number of defects reported reached 11,712, of which 970 were considered dangerous; 13 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment, - - - - -	1,171 - -	63
Cases of incrustation and scale, - - - -	2,094 - -	59
Cases of internal grooving, - - - - - -	61 - -	5
Cases of internal corrosion, - - - - - -	642 - -	8

* To make this clear, consider the boiler to be cut in two at the middle, the inner ends of the two halves being both attached to the middle hanger, as at present. Then this hanger would hold half the weight of each half of the boiler; that is, it would hold *one-half of the weight of the whole boiler*.

Nature of Defects.	Whole Number.	Dangerous.
Cases of external corrosion,	865	32
Broken and loose braces and stays,	144	65
Settings defective,	264	16
Furnaces out of shape,	426	32
Fractured plates,	188	47
Burned plates,	162	10
Blistered plates,	192	1
Cases of defective riveting,	1,665	106
Defective heads,	47	15
Serious leakage around tube ends,	2,002	288
Serious leakage at seams,	396	24
Defective water gauges,	416	98
Defective blow-offs,	170	30
Cases of deficiency of water,	18	2
Safety-valves overloaded,	55	19
Safety-valves defective in construction,	61	20
Pressure-gauges defective,	540	26
Boilers without pressure-gauges,	3	3
Unclassified defects,	130	1
Total,	11,712	970

Boiler Explosions.

SEPTEMBER, 1895.

(216.) — A boiler exploded on August 24th, at the Somaceo Mills, at Palermo, Cal. The mills were destroyed, and five persons were killed and twenty injured.

(217.) — On August 26th a boiler exploded at Minster, Ohio. Frank Busse, Carl Garrouss, and Henry Garrouss were fatally injured. Busse's skull was fractured, and the other men were injured internally.

(218.) — A boiler in George T. Houston & Co.'s large saw-mill, at Bixbee, near Armory, Miss., exploded on August 28th. Alonzo Bean was killed instantly, and Rufus Paine received injuries from which he died a few hours later.

(219.) — The boiler of the Wharf Company's pile driver at Galveston, Texas, exploded on August 28th. Thomas Cullom, the fireman, was seriously scalded and burned.

(220.) — On August 29th, the boiler of Berry Bros. steam cotton gin, eight miles east of Corsicana, Tex., exploded, demolishing the building, killing two men, and injuring several others. The gin was working smoothly on its fifth bale, and Mr. Lee Berry, the engineer, stated that the gauge showed 100 lbs., which was the pressure regularly carried by the boilers. The building was wrecked, and John Berry was killed. Lee Berry was covered with brick and other debris, and fatally injured. A Mr. Hardwick, for whom the cotton was being ginned, was blown thirty feet and slightly injured.

(221.) — A boiler exploded on August 29th, in John Flaugh's saw-mill, about twelve miles east of Huntington, Ind. Jacob Flaugh (a son of the proprietor), and Frank

Fahl were killed, and John Flaugh, Jr., was buried under a pile of debris, and somewhat injured. The mill was totally wrecked, and the noise of the explosion was heard for miles around. [The foregoing accounts were received too late for insertion in the August list, where they properly belong.— ED.]

(222.) — On September 2d, a boiler used in drilling an oil well at Hydetown, near Titusville, Pa., exploded. The boiler was blown to fragments, but fortunately nobody was injured, although there were nine persons in the immediate vicinity. Samuel R. Wilson, the tool dresser, had just been at the boiler, and had returned to the derrick when the explosion took place. He states that there was plenty of water in the boiler, and that the steam gauge, which was thirty pounds "shy," registered sixty pounds, making the actual steam pressure ninety pounds. Portions of the boiler were found 1,800 or 2,000 feet away.

(223.) — A hot-water boiler exploded, on September 5th, in the kitchen of the Pennsylvania Training School, at Elwyn, Pa. Mary Leypoldt had her left arm and shoulder badly scalded. The boiler was wrecked.

(224.) — A boiler exploded on September 5th, in the Oscoda Lumber Company's mill at Oscoda, near Bay City, Mich. The roof of the boiler-house was blown off, and the fireman, Edward Ely, was severely scalded. He will recover.

(225.) — On September 5th, a threshing machine boiler exploded on William Cuthbertson's farm, at Ripon, near Wheatland, N. D. Fireman Louis Berry was killed. Engineer John Buddie was fearfully injured, and died some days later. Peter Broderick was also badly scalded, and may die. The boiler and engine were literally blown to pieces.

(226.) — A boiler exploded, on September 6th, in Cladfelter's mill, at Hatton, near Marshall, Ill. The mill was torn to pieces, but the only person injured was Albert Gaby, who was somewhat scalded.

(227.) — A threshing machine boiler exploded, on September 7th, at Penn, near Devil's Lake, N. D. George Bail's leg was crushed, and he may die; Philip Lonsell had a rib broken; Andrew Nelson was scalded; and Trefle Bail's arm was broken in two places.

(228.) — A boiler exploded in the Lovejoy machine shops, at Richmond, Mich., on September 9th. Fortunately no one was in the vicinity at the time.

(229.) — One of the four boilers in the Marine City Stave Co.'s salt works, at Marine City, Mich., exploded on September 10th. The boiler-house was completely demolished, no part of it being left standing. Roswell Heath, who was firing the exploded boiler, was fearfully scalded about the back, neck, shoulders, and arms, and badly bruised about the face. Charles Essenberg was also severely bruised about the face, and terribly scalded about the body and hands. It is almost certain that Essenberg cannot recover, and Heath's recovery is also doubtful. The exploded boiler was repaired, last spring, at an expense of about $1,200, and was also tested, hydrostatically, to 100 lbs. At the time of the explosion it was carrying only 60 lbs. The property loss is variously estimated at from $10,000 to $20,000.

(230.) — A boiler exploded on a ferryboat at Decatur, Neb., on September 11th. Nobody was injured.

(231.) — One of a battery of twenty-four boilers, at the Logan Colliery of L. A. Riley & Co., at Centralia, near Shamokin, Pa., exploded on September 11th. The parts of the exploded boiler were hurled about 200 yards, and seven other boilers were displaced. A piece of iron crashed through an adjoining engine house and badly injured Harry Hunter and John Coolick. The property loss is about $5,000.

(232.) — A boiler exploded, on September 12th, in James Reed's quarry, at Bay View, near Gloucester, Mass. The explosion occurred at night, and nobody was injured.

(233.) — The boiler of F. M. Cates' cotton gin, near Waynesboro, Ga., exploded on September 12th. Five men were badly scalded and bruised, and two of them will die. The exploding boiler cut down a gum tree eight inches in diameter, which stood sixty yards from the gin, and then continued in its course for thirty yards more, before striking the ground. Seventy feet of shed were blown entirely away, and half of the boiler setting was blown down.

(234.) — F. E. Crosby was fatally wounded, on September 13th, by a boiler explosion in Mayfield, Ky. James Kimball was also badly scalded.

(235.) — On September 13th a boiler exploded in L. C. Fritch's stave mill, at South Huntingdon, Pa. Blair White, one of the engineers, received an ugly bruise, but the other employés providentially escaped injury. Considerable damage was done.

(236.) — An oil-well boiler exploded on September 13th, on the Zoda farm, at Jerry City, near Bowling Green, Ohio. James Fisher, the pumper on the lease, was killed.

(237.) — On September 18th a boiler exploded in Frank Weekly's mill, at Proctorville, near Central City, West Virginia. Mr. Weekly was blown to pieces. George Matthews was also instantly killed, his body being found fifty yards away. William Turner, the engineer, was badly cut about the head, and cannot live. Several other hands were injured in a lesser degree. We have not seen any estimate of the property loss.

(238.) — A boiler exploded on the night of September 20th, on the C. & P. dock, at Cleveland, Ohio. Nobody was injured, and the damage was not great.

(239.) — On September 20th, a threshing-machine boiler exploded on Clement Joyce's farm, near Skaneateles, N. Y. Charles King and Albert Ogden were painfully scalded, but it is believed that they will recover. The property loss is estimated at $4,000.

(240.) — A boiler in use at the Montgomery County Infirmary, six miles west of Dayton, Ohio, exploded on September 21st. Paul Butonhorne and Pearl Rhodes were killed, and James Hoolan, William Johnson, Mary Miller, and Frederick Ulmer were severely injured. It is feared that Hoolan may not recover, as he received a deep cut in the abdomen. The building containing the insane ward was badly wrecked.

(241.) — On September 23d, a new hot-water heating boiler exploded in the dry goods store of H. F. Winders & Son, at Findlay, Ohio. Flying pieces of iron buried themselves in the walls and ceiling, the front and rear of the storeroom were blown out, and hot water was thrown everywhere. Isaiah Earlywine and D. C. Ford were slightly injured.

(242.) — Two plain cylinder boilers exploded, on September 24th, at the Enterprise Colliery, Shamokin, Pa. John Rodonk was seriously scalded. The boiler-house was wrecked and several other boilers were displaced. The property loss was about $2,500.

(243.) — On September 26th, the back head blew out of a threshing-machine boiler in Luxemburg, near St. Cloud, Minn. Martin Ahels, the engineer, was instantly killed. His body was hurled ninety feet, passing through a fence on the way.

(244.) — A boiler exploded, on September 28th, on the Hamlin Ranch, near Delano, Cal. Walter Garwood was instantly killed. William Miller had both legs broken, and was injured internally. Louis Sagacy was scalded slightly, and William Rowlee and several others were also slightly injured.

(245.) — Samuel Sinsibacker was terribly injured, on September 29th, by the explosion of a boiler at Ulrichsville, near Cleveland, Ohio.

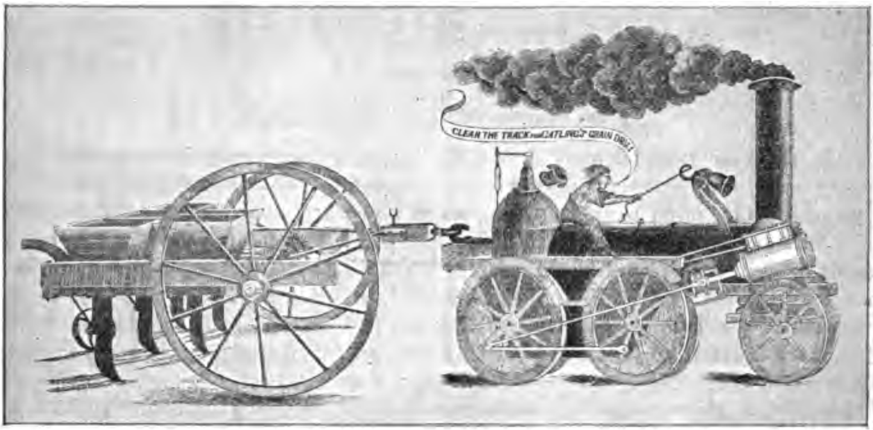
(246.)— On September 30th a boiler exploded in the bone factory at Pelham, near Lowell, Mass. The building was completely demolished, but fortunately nobody was injured.

The Story of Two Inventions.

In the year 1838, Richard Jordan Gatling, now the famous inventor, was then a young man in his twentieth year, working on his father's farm in North Carolina. He had made up his mind to go into business as a country store-keeper at the cross-roads near his home, and as his father favored the project, he went to Norfolk to buy his goods. While at the hotel in that city he heard a discussion about a trial that was to come off the next morning, at the Navy Yard, of boats with submerged wheels, and learned that the Navy wanted such a thing, and had offered a prize for the best device. A man named Harris had made a boat with lateral submerged wheels, and was to exhibit it that day. Young Gatling went down and saw the boat, and heard the projector's description of his invention, but was not favorably impressed with it. Harris died, and a man named Hunter took it up, and persuaded the Government to build a boat on his plan; but it never succeeded.

Gatling went home and pondered over the boat he had seen, and its disadvantages, and finally got up a model boat on a principle of his own, which was the "propeller," as it is now styled. The model was about 18 inches long, and its power was derived from a whalebone spring, which, by unwinding a cord from a shaft, ran the little pioneer "propeller" up and down the basin which he had constructed from the fish-pond on his father's premises. The boat worked successfully, and was the wonder of his family and the neighbors. The young inventor was so firm in the idea of the value and feasibility of his invention for propelling vessels that he asked for permission to go to Washington at once and get it patented; but his father was skeptical, and it was over seven months before Gatling got started for the Capital. It was then winter, and on his arrival at Annapolis the ice was so thick that an ice-breaker had to be used to reach Baltimore. Arriving at Washington, he left his model at a hotel and went at once to the Patent Office. Being a country lad, and rather shy, he thought he would first look around the office (it was a small concern then) and see if he could discover anything there like his own invention. Not seeing anything of the sort, he went back to the hotel, and wrapping up the model in a paper, took it under his arm and returned to the Patent Office. He explained to the man in charge of the models what he wished, and asked if there was anything in the office like his model. He was informed that only three or four days previous "a man by the name of Ericsson" had deposited a similar model, and, taking Gatling into a small room which the young man had overlooked in his preliminary survey, the attendant showed him Ericsson's model, which was almost identical with his own. The young inventor was nearly heartbroken, and returned home discouraged. At that time the idea of claiming priority did not occur to him. He supposed that the first man in the office with his model was the "best fellow." It is quite needless to speculate here as to who was the *first* to invent this great improvement, for at that time Gatling had not heard of Ericsson, nor was Ericsson probably aware of the existence of Gatling. Had Gatling known then as much of patent law as he learned afterward, the question of priority would have no doubt been settled.

Time, however, heals all wounds; the propeller was laid aside, and the inventive mind of Gatling busied itself with other matters. In 1842 the young man invented a



FROM AN OLD ADVERTISING CIRCULAR, ISSUED BY DR. GATLING IN 1845.

machine that was the pioneer in sowing grain by machinery, his machine being first used for sowing rice; but as the amount of rice raised was small in comparison to other grains, the sale of the machine was limited. In 1844, while clerk in a dry-goods house in Market street, St. Louis, Gatling read in an English paper that some one in England had invented a machine for sowing wheat in drills, which had largely increased the crop. He immediately took up his rice-sowing machine, and giving up his position as clerk, turned his energies to the development and adaptation of his machine for the sowing of wheat. He had the first lot of improved machines made in St. Louis. They sold fairly well, but the farmers objected to the regular cash price, and doubted its working well. In order to prove his faith in his own machines, and to sell them, he bargained to sell the machine for the difference between the crop raised on 20 acres sown by his machine and 20 acres sown broadcast. The difference being about 5 bushels to the acre in favor of the drill, he sold many machines at a larger price than he originally asked for them. The next season the success of the first was his advertisement, and the wheat-drill was an established agricultural implement.

F. W. P.

THE danger of having a poor fireman, or of giving him too many things to do, in addition to his regular task of caring for the boiler, is daily illustrated by incidents in our business. At a recent external inspection of an upright boiler, for example, our inspector found a hot fire burning, with the fire door shut, and 100 lbs. showing on the steam gauge, although the boiler is not supposed to carry over 60 lbs. The safety-valve was stuck. The try-cocks were out of order and broken, and there was no water showing in the glass gauge. The lower try-cock, when opened, showed very blue steam. After deadening the fire with fresh coal, and allowing the boiler to cool down somewhat, the injector was started, and it was fully half an hour before the water showed at the lowest try-cock. Of course it would be absurd to continue insurance upon a boiler so neglected. The policy was therefore canceled.

An interesting article by Dr. H. C. Hovey, on "The Isles of Shoals," is published in a recent issue of the *Scientific American Supplement.* We cannot print it in full, but the following abstract, which appeared in the *Scientific American*, may be of interest :

The Isles of Shoals are nine miles out to sea from Portsmouth, N. H. They consist of nine small islands, five of which belong to Maine and four to New Hampshire. Although discovered in 1614 by Captain John Smith, and visited since by thousands of tourists, their geology has been neglected. After briefly giving a few historical facts, Dr. Hovey tells what he found during his explorations among the rumpled and twisted rocks of this group. There are proofs that Star, Haley, Cedar, and Malaga islands are undergoing a process of elevation, having risen six feet within fifty years. Pot-holes that once were at tide level and used by the fishermen as basins for cleaning fish, are now a hundred feet back from the sea, and six feet above the ordinary tides. The channel between these islands was formerly six feet deeper than it now is. The petrography of the islands has only been partly worked out; but the signs of igneous action are impressive. Dikes of diorite and gneiss and seams of quartz and feldspar run in every direction. The trap rock yields more readily to the action of the sea than do the granite rocks, and on being worn away, leaves channels through which the waves rush with violence. In some cases the work is not yet complete, and the huge basaltic blocks lie like gigantic stairs, thus justifying the etymology of the word *trap*, which comes from "trappa," meaning steps.

A remarkable column on Appledore Island is described: it is eleven feet in diameter, and must once have been as much as twenty-five feet high, but now has been singularly sliced off by the waves. In shape it is sharply hexagonal. The rock is light colored granite, crushed and baked, and protrudes from a mass of black gneiss, beyond which are walls of white granite. It is an altogether unique occurrence.

The violence of the waves that beat about these islands would seem incredible were not so many proofs at hand. Some of them are given by Dr. Hovey. The Leightons, who own most of the islands, built a stone wall six feet high and six feet thick, to protect their Appledore hotel; but a single winter storm broke it down and scattered the stones in every direction. Last winter a storm carried great boulders completely across the islands. A boulder weighing many tons was tossed by the waves and lodged on the cliff of White Island, fifty feet above the sea level. Lightning has also done its share in the work of demolition. Glacial action has been powerful, too. These causes combined — glacial, aqueous, igneous, and electrical — have rent these islands apart, severed them from the mainland, and ground up their rocks into the masses of sand that are now piled up as dunes about the mouth of the Merrimac.

The Locomotive.

HARTFORD, NOVEMBER 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

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Bound volumes one dollar each. (*Any volume can be supplied.*)

Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

AMONG the boiler explosions given in our list this month, we find another good example of popular ignorance of the extreme violence of these occurrences. "Some miscreant blew up the boiler in James Reed's quarry last night," the account says, "by putting a keg of powder into it, and then touching it off." We don't doubt that this appeared, to those who heard the explosion, to be the only possible explanation of the affair.

OUR esteemed contemporary, the *Popular Science Monthly*, appears this month in a somewhat new dress. The most striking change is in the title, which has now become *Appleton's Popular Science Monthly*. The body of the magazine is substantially the same as before; but in the latter part we note some minor typographical changes, and a somewhat different plan of arranging the book notices. The contents of the November issue are fully up to the high standard that the *Monthly* has set for itself in the past.

PROF. John G. Flather, of Purdue University, has written a little volume on *Rope-Driving*, in which he discusses the transmission of power by means of ropes. The subject is well covered, and the book is freely illustrated, containing ninety-two photo-engravings, some of which are half-tones. We heartily commend the volume to those seeking information on the subject of which it treats. (New York, John Wiley & Sons. Price $2.00.)

MESSRS. John Wiley & Sons also issue *The Encyclopedia of Founding*, by Mr. Simpson Bolland, whose books, *The Iron Founder* and *Iron Founder Supplement*, we have noticed in former issues. The present work is arranged, as its title indicates, after the manner of an encyclopedia, the various entries being given in alphabetical order. There are a great number of cross references which add to the value of the book materially. The information given is extremely varied, and includes pretty much everything that a founder would want to know, from the crudest general principles of the art up to such refinements as the casting of handwriting and embroidery impressions. We think it would have been clearer in some places if illustrations had been used; but on the whole the book is quite satisfactory, and forms a worthy successor to Mr. Bolland's other writings. (Price $2.00.)

We publish, in this issue, an article entitled "The Story of Two Inventions," by Col. F. W. Prince, who has known Dr. Richard J. Gatling intimately for many years, and is now associated with him in business. The story of the propeller is especially interesting, though not more so, perhaps, than that of the grain drill. Some of our older readers may remember the quaint advertising circular that was posted about in country stores and other such places, half a century ago, and from which our illustration is taken. The hard-handed sons of the soil used to gather about that circular, and remark, with some freedom of speech, upon the discomfort that the engine-driver would surely experience, if he didn't change his base. But this good-natured criticism only drew attention more widely to the circular, so that it proved a very good advertisement, and a great many machines were sold.

We have received a copy of Mr. Thomas Pray, Jr.'s, *Steam Tables and Engine Constants*, which is published by the D. Van Nostrand Company, 23 Murray street, New York. It contains a considerable number of tables relating to steam and steam engines, and should prove very useful. Mr. Pray says that "every table in this work was computed, not copied"; and he adds that the data upon which they are based were taken directly from Regnault, Rankine, and Dixon. Originality is uncommon in tables of this kind, and should lend especial interest and value to the present volume. We note with pleasure the following lines in the preface: "The author has a full translation of the important papers of Regnault now nearly ready to publish, and it will follow this volume with only a short interval." The engineering world will be deeply indebted to Mr. Pray for the translation that he promises.

Louis Pasteur.

Louis Pasteur, the great French chemist and bacteriologist, died at his home at St. Cloud, France, on September 28th. Dr. H. W. Conn, in his memorial article in *Science*, says of him: "Never has the world been called upon to lament the death of one whose life was so full of gifts to humanity as that of Louis Pasteur. Others have lived with equal genius, others there have been whose influence upon thought has been equal or greater. Others have achieved an equal reputation from achievements of various kinds; but no other man in the history of the world has given to mankind so many valuable gifts as those which have come from the labors of Pasteur." He was born at Dole, France, on December 27, 1822. He entered the École Normale in 1843, and took his doctor's degree four years later. His life was extremely active, and he held a considerable number of professorships. "On the occasion of M. Pasteur's seventieth birthday," says the *Scientific American Supplement*, "a most striking illustration was afforded of the esteem in which he was held in France. The ceremony took place in the great amphitheatre of the Sorbonne, which was crowded by a brilliant assembly of the foremost men of the day in science and literature. M. Pasteur entered the amphitheatre leaning upon the arm of his son, and upon that of the President of the Republic. All present rose to their feet and greeted the hero of the day with cheers. It is seldom that such an ovation has been given to a man of science, and M. Pasteur was much affected by the touching ceremonies of the occasion. The magnificent laboratories of the Pasteur Institute in Paris were built by popular subscriptions, and really afford the best form of monument which could be erected; and it doubly honors the great scientist in its being raised during the lifetime of the man in whose honor and for the furtherance of whose work it was designed." He is best known for his work in connection with fermentation, and for his discovery of the cause of, and cure for, the silk-worm disease (*pèbrine*), which had threatened the silk industry of France with destruction. He is also famed for his researches on *anthrax*, the dreaded disease that had invaded the stock yards of France, and which destroyed, at one time, over a quarter of a million sheep annually. It would be impossible to recite all his achievements. His method of treating hydrophobia by inoculation has the melancholy interest of being the last great discovery that we owe to Pasteur alone. Considering his labors as a whole, it is difficult to conceive of the vast increase in material wealth that has resulted from them; and we must add Pasteur's name to the immortal trio of whom Huxley said*: "I weigh my words when I say that if the nation could purchase a potential Watt, or Davy, or Faraday [or Pasteur], at the cost of a hundred thousand pounds down, he would be dirt cheap at the money. It is a mere commonplace and everyday piece of knowledge, that what these three [four] men did has produced untold millions of wealth, in the narrowest economical sense of the word."

The Vitality of Seeds.

There are many persons who still believe that corn and other grain found in ancient Egyptian mummy cases has been made to grow when planted under proper conditions. We believe that there is no sufficient evidence that this is so; but we know that seeds can often grow after being exposed for a long period to conditions that would seem to be absolutely fatal to life.

An interesting case of this kind came to our attention a short time ago. Mr. J. B. Pierce, Secretary of this company, bought the place where he now lives in the year 1872. At that time there was a flower garden back of the house, but not caring to be troubled with it, he spaded it up and sowed it down to grass seed, and for twenty-one years he pushed a lawn-mower industriously over the spot, and all memory of the flowers faded away. In 1893, however, — twenty-one years after the garden was "turned down,"— Mr. Pierce planted a small apricot tree within the area in question, and the little circle which he left free from grass around the base of the tree soon showed signs of life, and produced a vigorous crop of *petunias*, the plants being about three feet high at maturity. One year later the entire tract was spaded up and set out with chrysanthemums and sweet peas. This treatment seemed especially advantageous to the long-dormant petunias, for they came up in great profusion, and fully two bushels of them were pulled up and thrown away as weeds. This year the petunias, apparently discouraged, did not show up; but in place of them there came a sensitive plant, which is still prospering in a flower-pot in the house!

THE EDITOR'S CORRECTION.— Mr. and Mrs. M. Lowentritt have gone to Pittsburg to visit their son Joe. (Friday's *Blizzard.*)

With the exception that Mr. and Mrs. Lowentritt did not go to Pittsburg, and that they have no son Joe, the above item is correct. The chap who wrote the item tried to say that Mr. and Mrs. Ludwig Mayer had gone to Pittsburg. The similarity in the names is readily apparent.— *Oil City Blizzard.*

* Quoted by Mr. George Bruce Halsted, in *Science*.

Scientific Knowledge in China.

China has been so prominently before the public for the past few years that an article that appeared in a recent issue of the *Revue Scientifique*, on the knowledge of science possessed by the Chinese, seems very timely. It cannot be denied that the Chinese of the present day have very elementary ideas on any branch of science; but it has not always been so. In early times, as far back, even, as 2000 B.C., we find that science in China had reached a fairly advanced stage. Undoubtedly the Chinese possessed a great knowledge of astronomy: inscriptions have been found which prove this. In the "Chou-king," a book of records, we read that Emperor Yao, who reigned about 2357 B.C., did much to advance the study of this science. He ordered his astronomers to observe the movements of the sun, moon, and stars, and showed them how to find out the commencement of the four seasons by means of certain stars. We read, also, that he told them that a year consists of a little less than 366 days, and, as he divided the year into lunar months, he taught them the year in which the additional lunar month ought to be included. It is also known that the Chinese had the annual calendar, that they observed the planets Mercury, Venus, Mars, Jupiter, and Saturn, that they were able to calculate eclipses, and that they knew the difference between the equator and the ecliptic. It is quite probable, however, that the ecliptic was not known until the Musselmans occupied the Mathematical Tribunal, which they held for three centuries.

We see, therefore, that their knowledge of astronomy was quite extensive. The *meridian* was apparently unknown. M. Chavannes, who is at present professor of Chinese at the College of France, says that it is not mentioned in any astronomical book. As a substitute a certain star was observed at the same hour, according to the times of the year, note being taken of its positions with regard to the horizon.

Astronomy has always been closely connected with astrology. By means of astronomy the time was ascertained for the numerous public ceremonies recorded in the imperial calendar. It likewise regulated the affairs of the government. But the calendar has long since ceased to be used for this latter purpose, and the majority of the Chinese population merely look upon it as a means of continuing the mysterious ceremonies and oracles connected with the different positions of the planets. It is ordered in the "Collection of the Laws" that at each eclipse ceremonies should be gone through to deliver the eclipsed sun or moon. At this time, therefore, an alarm is sounded on the drums, the mandarins arrive armed, utter many objurgations, and thus deliver the endangered bodies.

In the seventeenth century certain Jesuit missionaries arrived in China. On seeing the low state into which the Mathematical Tribunal had fallen, they offered to help it. They found an observatory containing many instruments, which shows plainly that this branch of science had at one time reached an advanced stage. Its subsequent decay is not to be wondered at, when we remember that twenty-two dynasties were brought on the throne by actual revolutions. Nor was the decay confined to astronomy. According to the ancient books and traditions we find that various branches of science had reached a considerable degree of development.

The Emperor Kang-hi, who reigned in the seventeenth century, had a great love of study himself, and endeavored to advance the general education in China. The Jesuit missionaries instructed him in geometry and physics, and he translated some text-books into Chinese. The Chinese have usually been credited with the invention of gunpowder; but a certain document has been found by Archimandrite Palladius, a Russian sinologue, stating that in the ninth century a Persian regiment, under the Chinese sovereign, made known a material similar to wild-fire, which was afterwards used for fireworks.

Apparently chemistry has never been studied, unless by a certain sect, the Tao-tse, who spent all their time endeavoring to discover the philosopher's stone and the elixir of life. The Chinese have little knowledge of geology. The mines have been worked without any machinery, and are not very deep; fire-damp, therefore, has rarely been found troublesome. Coal was mined at as early a time as 200 B.C., in the dynasty of Han; and although the mode of extraction was primitive, enough was obtained to satisfy all wants. About 1861 the government handed the exploration of the mines over to American prospectors. The work, lasting from 1862 to 1864, was directed by Prof. Pumpelli, who, at its termination, sent the emperor a report and a map of the coal-fields. The Smithsonian Institution of Washington has had these documents published, and they have also appeared in the diplomatic correspondence of the United States for 1864. Later on Baron de Richtofen did similar work, and found that the coal-fields in China are even more extensive than those in North America.

Research work has not been carried far in natural science. In zoölogy their classifications are quite wrong. The drawings in zoölogical and botanical books often can be scarcely recognized. Their most ancient work on botany dates from 2700 B. C., and is a treatise written by the Emperor Shen-nung; it is merely enumerative. Another work, the "Rh-ya," dates from 1200 B. C., and shows signs of progress. The "Pentsao," an encyclopedia, is of little value, according to M. Bretschneider. This Russian investigator speaks of the Chinese as follows: — "It is an undeniable fact that the Chinese do not know how to observe, and have no regard for truth; their style is negligent, full of ambiguities and contradictions, and teeming with marvelous and childish digressions." In a more recent communication, however, M. Bretschneider retracts his words, and says that it is more that the Chinese *will not* observe than that they *cannot*, for Lichi-Tchen, author of several interesting pamphlets, brings forward many facts concerning cultivated plants.

The medical science of the Chinese is very elementary. Occasionally, here and there, a successful doctor is to be found. Their lack of knowledge in this direction is not to be wondered at, since Buddhism forbids dissection of bodies. In the temple of Confucius a bronze figure is to be found, on which all the different parts are marked where the surgical needle may be applied. This needle is practically the only instrument used in the profession.

The height of civilization in China was reached at the end of the reign of Kang-hi. The gradual decline is supposed to have commenced with the Tartar domination.— *Nature* (adapted).

Where Our Woods Come From.

Mr. A. B. Green contributes an interesting article, under this heading, to the *Pratt Institute Monthly*. A selection from it is given below :

The extent and density of the forest growth of the United States, at the beginning of our existence as a nation, surpassed that of any land of equal extent on the globe; in the number of species, both deciduous and evergreen, it exceeded by five times the forests of Europe. Such a growth, at the time of the landing of the first settlers, spread almost unbroken from the Atlantic to the Mississippi ; while an equally dense forest,— chiefly of conifers, many of an enormous size, — occupied the Pacific slopes.

For a study of the forest growth of the United States, we may separate it into three portions. First, a belt of fir, pine, and spruce, extending along the northern border of the United States from ocean to ocean, and reaching southward to the neighborhood of the 40th parallel. Fir is the name often given to a large variety of coniferous trees, of a pyramidal form and regular proportions, although it is properly applied to only one family. The true fir is found on the Pacific coast, particularly in the extensive forests of Washington and Oregon, where it often attains immense size, and at the present time supplies most of the ships' masts used in this country. The second portion is a belt of the hard, or yellow pine extending from the Atlantic Ocean to the Rocky Mountains, and northward to the 40th parallel. The third portion contains a growth of hard woods extending generally all over the country, from north to south, and reaching its greatest development in the region between the 35th and 40th degrees of latitude.

Nearly all the States produce some lumber ; but in many, the product is not sufficient to supply even the local needs, while in others thousands of feet are daily wasted because of its abundance. The chief sources of supply of the woods most commonly used are as follows : White pine, so largely used in house-building and furniture throughout the Northern States, comes from the forests of Michigan, Wisconsin, and Minnesota. Maine formerly furnished considerable pine, but the supply in that State has diminished until all that it produces goes to supply the home market ; New York and Pennsylvania also produce white pine, but only in limited quantities. To-day Michigan stands first as the greatest pine producing State ; the value of its lumber product, with that of Wisconsin and Minnesota, is equal to one-third of the total value of all timber produced in the United States. Spruce is obtained in large quantities from Maine, Washington, and Oregon, and is imported into the United States very largely from Canada. Hemlock is found in Pennsylvania ; it is poorer and cheaper than spruce, but is used as its substitute in the frames of houses.

Hard, or yellow pine, used in the construction of heavy buildings, is supplied by a belt which, beginning in Virginia, passes southward through North and South Carolina, Georgia, and Florida, and extends westward into Texas. This tree reaches its greatest development in Georgia, and it is here that it is most extensively cut. Hard woods, ash, maple, oak, and cherry, are scattered through almost every State east of the Mississippi; but there are districts where the growth is especially dense. The first region is that included in the western parts of West Virginia, North and South Carolina, Eastern Kentucky, and Tennessee; while a second area extends into Mississippi and produces some fine hickory and oak lumber. Black walnut is obtained from the slopes of the Alleghany Mountains in West Virginia, Kentucky, and Tennessee. It is also abundant in Northern Mississippi and Texas.

Whitewood, obtained from the tulip-tree, comes chiefly from the slopes of the Alleghany Mountains in Tennessee and North Carolina ; it is also supplied from the southern portions of Indiana and Illinois, in the vicinity of the Ohio and Wabash Rivers. Whitewood is extensively used in the South as a substitute for white pine, and is one of the largest trees in the East. The red-gum is found abundantly along the bottom-lands of the Mississippi River in Mississippi, Tennessee, and Arkansas. Cypress is found in Georgia and in all of the Gulf States. Cypress is the substitute for white pine in the Southern coast States, and is largely manufactured into doors, sash, blinds, and shingles. Our red cedar comes mainly from Florida. Formerly Alabama was the great cedar State, but her supply is now almost exhausted.

The California redwood grows along the northern half of the coast of California, where it is often found over fifteen feet in diameter and from one hundred to two hundred feet in height. In this region is found the heaviest continuous belt of forest growth in the United States ; it extends from northern California through the western parts of Oregon and Washington, and eastward into Idaho. These forests are almost wholly of redwood, fir, spruce, and white cedar, with very little hardwood.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. XVI. HARTFORD, CONN., DECEMBER, 1895. No. 12.

The Horse-Power of Boilers.

The expression "horse-power of a boiler," although frequently used in engineering practice, is highly unsatisfactory on account of its indeterminateness. No one can calculate what actual horse-power can be realized from a boiler, without knowing what sort of an engine is to be used: for a boiler which gives fifty horse-power with a small, non-condensing, slide-valve engine, may give four or five times as much power when used in connection with an engine of more improved design. Nevertheless, the expression "horse-power" has became a trade term, and custom has given to it a nominal meaning which was first definitely fixed by the Centennial Commission. After a careful discus-

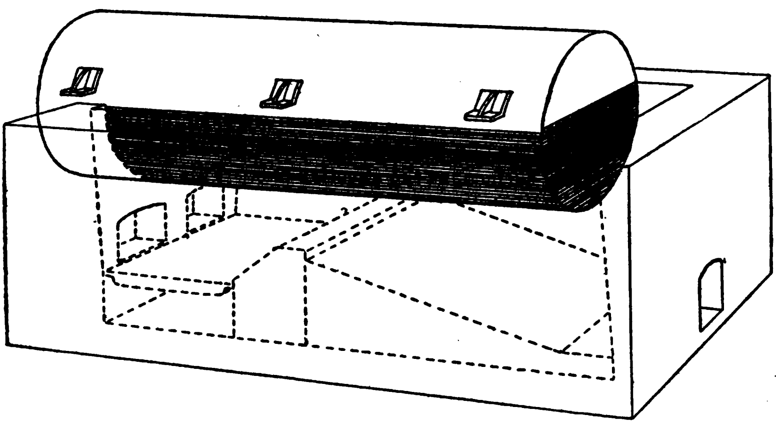

DIAGRAM SHOWING THE HEATING-SURFACE OF A BOILER SHELL.

sion, the Commission concluded that with the engines then commonly in use, it was possible, in average good practice, to realize an actual horse-power from 30 pounds of steam per hour, the pressure being 70 pounds, and the temperature of the feed water 100° Fahr. This definition of the phrase "horse-power," as applied to boilers, has met with almost universal acceptance among boiler-makers and designers, so that when an order is given for a boiler of a stated number of "nominal horse-power" it is understood (in the absence of any agreement to the contrary) that a "horse-power" means the evaporation of 30 pounds of water per hour, under the conditions stated above.

In computing the horse-power of a boiler by the Centennial rule, or by any other rule, the first problem is to find the heating surface of the proposed boiler, which consists of all those parts of the shell, heads, and tubes, which are exposed to the direct action of the fire or of the hot gases that come from it. We shall proceed to consider these parts in detail.

The part of the *shell* which is exposed to the fire, is indicated by the heavy shading in the illustration. It extends from the back head to the rear surface of the front wall of the setting; and it is limited at the top by the side walls, where they extend inward and touch the boiler. To obtain this area with precision, we should know the exact length of the shaded area, and also the height of the side walls of the furnace; but in practice it is usually assumed that the shaded area is equal to one-half of the area of the entire shell (omitting the dry-sheet, of course, in case there is one). This simplifies the calculation very much, and yet the results correspond quite closely to the actual facts. The *front head* of the boiler is of little or no value as a heating surface, because, if the boiler is well designed, the temperature in the uptake does not greatly exceed the temperature of the boiler itself, and hence there cannot be any considerable absorption of heat through the front head. This head should therefore be entirely omitted in the calculation. The *back head* is more directly exposed to the heat of the furnace, and allowance is sometimes made for such heating surface as it contains. In our own practice we do not make allowance for the back head, however, because the only part of its surface which is available, in any case, consists in the small segments which lie between the tubes, together with a narrow strip around the flange and just under the back arch. While there might be some heating value to these parts when the boiler is new, we do not consider that they are worth taking into account after it has been used for a time, because scale is likely to form upon them; and even though the scale were not heavy enough to produce over heating, and consequent injury to the boiler, it might still be quite sufficient to destroy the efficiency of the head, when considered as a heating surface. The *tubes* are of great importance in computing the heating surface, because their combined area is very large, as can be seen in the numerical example that we give below. In computing the heating surface of a tube, we have first to consider whether we should take the internal or external surface, as the effective one. This question admits of discussion, and could only be settled definitely by actual measurement of the external and internal temperatures of the tube, when the boiler is in operation. If it were found, by experiments of this sort, that the tube, as a whole, is nearly as hot as the gases within it, then the *external* surface should be taken; while if the tube were proved to be hardly hotter than the water in the boiler, there can be no doubt that the *internal* surface should be taken as the effective one. We do not know that any such measurements have been made; and, in the absence of them, some engineers base the calculated heating surface upon the internal diameter, while others use the external diameter, and still others the average of the two. Our own practice has been to take the *external* diameter; and we believe that this course is justified by experience.

This point being settled, the next step is to find the area of the tube, by multiplying its outside circumference by its length — the circumference being found by multiplying the outside diameter by 3.1416. (The diameter of the tube is usually given in *inches*; so that if the surface is required in *square feet*, it is necessary to divide the given diameter (or circumference) of the tube by 12, so that it may be expressed as a fraction of a foot.) The area of one tube being thus found, we multiply it by the *number* of tubes, and thus find the united surface of all of them. This, when added to the heating surface afforded by the shell, gives the entire surface upon which the rated horse-power of the boiler is to be based.

A numerical example will make the rule plainer. Thus let it be required to find the heating surface of a 72-inch boiler, 18 feet long from head to head, with 92 tubes, each $3\frac{1}{2}$ inches in diameter. The diameter of the boiler being 72 inches, its circumference is

$$72 \times 3.1416 = 226.1952 \text{ inches.}$$

To express the circumference in *feet*, we divide this result by 12; thus

$$226.1952 \div 12 = 18.8496 \text{ feet.}$$

The length of the boiler, between heads, being 18 feet, the total area of the shell is

$$18 \times 18.8496 = 339.2928 \text{ sq. ft.:}$$

and

$$339.2928 \div 2 = 169.6464 \text{ sq. ft.,}$$

which is to be taken as the effective heating surface afforded by the *shell*. Passing now to the tubes, we find that the circumference of a 3½-inch tube is

$$3.5 \times 3.1416 = 10.9956 \text{ inches,}$$

which is equal to 0.9163 of a foot (since $10.9956 \div 12 = 0.9163$). The *surface* of the tube is then found by multiplying the circumference by the length; thus

$$0.9163 \times 18 = 16.4934 \text{ sq. ft.,}$$

which is the area of a single tube. The combined area of the 92 tubes that the boiler contains is therefore

$$92 \times 16.4934 = 1{,}517.3928 \text{ sq. ft.,}$$

which is the heating surface afforded by the *tubes*. Upon adding this to the heating surface afforded by the shell, we have

Heating surface of shell	= 169.6464	sq. ft.
" " " tubes	= 1,517.3928	"
Total effective heating surface of boiler	= 1,687.0392	sq. ft.,

or, in round numbers, 1,687 square feet. (It will be seen that the tubes are of far more importance than the shell, as has been already said, above.)

The foregoing method of calculating the heating surface of a boiler may be somewhat simplified, by arranging the computation in the manner indicated by the following

RULE FOR FINDING THE EFFECTIVE HEATING SURFACE OF A HORIZONTAL TUBULAR BOILER: Multiply the diameter of a tube (in *inches*) by the number of tubes, and to the product add the *radius* of the boiler (also expressed in inches). Multiply the sum by the length of the boiler, from head to head (expressed in *feet*), and then multiply again by the decimal 0.2618. The result is the effective heating surface of the boiler, in square feet.

This rule is the exact equivalent of the process explained above, and differs from it only in the fact that the *order* of the various operations has been changed, so as to make the numerical work somewhat easier. That it is really the same thing, and yet at the same time simpler in its application, is shown by the following solution of the problem given above:

(Diameter of tube) × (No. of tubes) = 3.5 × 92	= 322.
Radius of boiler (in inches)	= 36.
Sum	= 358.

Then, the length of the boiler being 18 feet, we have

$$358 \times 18 = 6{,}444;$$

and, finally, $6{,}444 \times 0.2618 = 1{,}687.0392$ sq. ft.,

which is identical with the result already obtained.

The heating surface of the boiler being known, the next step is to find what evaporative duty may be expected of the boiler, in ordinary good practice. To solve this part of the problem we have to know from experiment what amount of water can be economically evaporated by each square foot of heating surface per hour. The Centennial Commission considered that two pounds was a fair estimate. In our own practice we find that when the boiler is well designed, and the draft is good, an evaporation of 2½ pounds of water per hour may be had from each square foot of heating surface. In exceptional cases the evaporation may run as high as 3 pounds; but under ordinary circumstances it is found that 2½ pounds is all that can be reasonably expected. Accepting the estimate of the Centennial Commission of 2 pounds per square foot per hour, it follows that fifteen square feet of heating surface will be required for each "nominal horse-power" of the boiler; for at 2 pounds per square foot, the evaporation on 15 square feet will be 30 pounds per hour, which is the amount of steam required, in the Commission's definition of the "horse-power." The nominal horse-power of a boiler would therefore be found by dividing the heating surface (in square feet) by 15. If the data afforded by our own experience be accepted, it follows that the boiler will have one nominal horse power for every 12 square feet of heating surface; for if each square foot evaporates 2½ pounds per hour, the total evaporation on *twelve* square feet will be 12 × 2½ = 30 pounds per hour. Hence, in our own practice we calculate the nominal horse-power of a boiler by dividing the total effective heating surface (in square feet) by 12.

If it is desired to calculate the *actual* horse-power that a given boiler may be expected to furnish, we must first know something about the engine that is to be used. For the boiler merely *produces* the steam, and it is the *engine* which transforms the heat-energy of the steam into mechanical energy; so that if the engine is efficient, a large yield of mechanical energy may be expected; while if it is wasteful, the yield of mechanical energy will be much smaller, even when the boiler is worked just as hard as before. The duty of a given engine can usually be pretty closely estimated by a person who is familiar with the performance of other engines of the same type; and, in fact, large engines are often built by contract to run with a given steam-consumption per horse-power per hour. If the duty (or steam consumption) of the engine is known, the *actual* horse-power that may reasonably be expected from the boiler can be calculated by the following:

RULE FOR FINDING THE ACTUAL HORSE POWER: First find the heating surface (in square feet) as before. Multiply this by 2½, which will give the number of pounds of steam that the boiler can produce per hour. The evaporation thus found is then to be divided by the weight of steam required by the engine that is to be used, per horse-power per hour, and the quotient is the actual horse-power that may reasonably be expected when the proposed boiler and engine are run together, under favorable conditions.

In conclusion we shall give a numerical example illustrating the application of this rule, taking, for this purpose, the boiler whose heating surface has already been computed. The heating surface being 1,687 square feet, the evaporative duty of the boiler, per hour, will be

$$1{,}687 \times 2\tfrac{1}{2} = 4{,}217.5 \text{ pounds.}$$

We will assume, first, that the engine is of the ordinary single-cylinder non-condensing form, and that it uses 30 pounds of water per horse-power per hour (which is the duty assumed by the Centennial Commission). The actual horse-power developed under such circumstances is then

$$4{,}217.5 \div 30 = 140 \text{ H. P.}$$

On the other hand, if the engine were of the triple-expansion, condensing form, with a steam-consumption of (say) 12.5 pounds per horse-power, the rule would give

$$4{,}217.5 \div 12.5 = 337.4 \text{ H. P.},$$

which is the actual yield of mechanical energy that could reasonably be expected with this engine and boiler.

Inspectors' Report.

OCTOBER, 1895.

During this month our inspectors made 10,091 inspection trips, visited 19,658 boilers, inspected 6,538 both internally and externally, and subjected 927 to hydrostatic pressure. The whole number of defects reported reached 12,941, of which 1,635 were considered dangerous; 61 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,118	48
Cases of incrustation and scale,	1,996	66
Cases of internal grooving,	99	9
Cases of internal corrosion,	661	31
Cases of external corrosion,	847	41
Broken and loose braces and stays,	156	64
Settings defective,	396	46
Furnaces out of shape,	479	17
Fractured plates,	245	41
Burned plates,	215	27
Blistered plates,	238	7
Cases of defective riveting,	2,111	542
Defective heads,	111	19
Serious leakage around tube ends,	2,219	366
Serious leakage at seams,	474	37
Defective water gauges,	471	83
Defective blow-offs,	204	68
Cases of deficiency of water,	25	9
Safety-valves overloaded,	114	24
Safety-valves defective in construction,	97	41
Pressure-gauges defective,	483	44
Boilers without pressure-gauges,	5	5
Unclassified defects,	177	0
Total,	12,941	1,635

Mr. J. R. Roosevelt, secretary to the United States Embassy, has presented to Lord Rayleigh and Professor Ramsay the check of the embassy for $10,000, being the Hodgkins prize awarded by the Smithsonian Institution, of Washington, for their discovery of a new element in the atmosphere. The recipients of the prize have also written a etter of thanks to the Smithsonian Institution.— *Scientific American.*

Boiler Explosions.

OCTOBER, 1895.

(247.) — A boiler exploded on October 1st, in Banister's bone mill, at Pelham, N. H. The mill was blown to atoms, and the building and machinery were completely wrecked. Fortunately nobody was injured.

(248.) — On October 1st a boiler exploded in Dale, Mitchell & Co.'s big mill at Alexanderville, Ga. Henry Carpenter, Jerry Meyer, and another man whose name we could not learn, were killed, and five other men were injured, among the injured being Henry Mitchell, the superintendent of the mill, and his son.

(249.) — Joel Beckwith & Co.'s stave factory, at Greencastle, Pa., was completely wrecked, on October 2d, by the explosion of one of the boilers. It does not appear that any one was seriously injured, and we have seen no estimate of the damage.

(250.) — A boiler exploded on October 4th, at the Franklin mine, near Seattle, Wash. R. M. Gibson and Philip Early were burned and otherwise injured, so that they died next day.

(251.) — A threshing-machine boiler, belonging to John Shy, exploded on October 5th, in Townsend township, Ohio. Six men were sitting in front of the boiler at the time, but they all escaped injury, the boiler passing directly over them, and striking the ground 100 feet or more away. The threshing outfit was blown to pieces and the fragments were scattered in all directions.

(252.) — A boiler exploded on October 6th, in Alexander J. Howell & Sons' soda factory, Westchester, N. Y. The fire department turned out, and found the boiler house reduced to a mere heap of bricks and iron. Frank Thorn, the night engineer, was killed, his body being found in the ruins under a pile of bricks. The property loss was about $5,000.

(253.) — On October 7th a boiler exploded in George W. Brown's saw-mill at Orr Station, on the Sherman, Shreveport & Southern railroad, near Greenville, Texas. The explosion occurred at noon, while the men were away at dinner; so that nobody was hurt. The mill and its contents were badly wrecked.

(254.) — The boiler in the washroom of the Lehigh Valley car shops, at Ithaca, N. Y., exploded on October 7th. William Tree, a cleaner in the wash gang, was badly scalded about the body and face. It is doubtful if he can recover. D. S. Williams was also quite badly injured. The building was completely wrecked.

(255.) — One boiler in a battery of ten exploded on October 7th, at the Sterling colliery, Shamokin, Pa. Daniel McIntyre, an engineer, received injuries which are feared to be fatal. The boiler-house was demolished, and the property loss is estimated at about $2,000.

(256.) — A locomotive boiler exploded on the Philadelphia & Reading railroad, near Wernersville, Berks county, Pa., on October 7th, wrecking the engine. Engineer Charles Frill and Fireman John D. Fegley were badly injured. Fegley was hurled into a neighboring field.

(257.) — A boiler exploded on October 8th, at the Wharton Iron Mine, Hibernia, N. J. The boiler-house was torn to pieces, and the whole village was shaken up. Engineer Milton Smith was hurled twenty feet into the air, and was badly hurt and scalded;

Philip Vosburgh was also scalded, and John Clark, William Kelley, John Malone, and Michael Ryan were painfully bruised. The property loss is estimated at from $10,000 to $15,000.

(258.) — On October 9th a threshing-machine boiler exploded near Wakeman, Ohio. C. B. Canfield was seriously injured about the back.

(259.) — The explosion of a threshing-machine boiler on October 10th, near Mount Lake, Minn., resulted in the deaths of Joseph Schumacher, Jasper Malette, and two other men, whose names we could not learn.

(260.) — One of a battery of fifteen boilers exploded on October 11th, at the Delaware mine of the D. & H. Coal Company, at Mill Creek, near Wilkesbarre, Pa. The explosion was felt all over the town, and windows and dishes were broken in many of the residences. Nobody was hurt. The exploded boiler was used to hoist coal, and to operate the breaker engines and pumps, and was not connected with the fan. Hence the explosion did not interfere with the ventilation. The men in the mine were taken out by way of another opening.

(261.) — A small boiler used for furnishing heat for a big incubator belonging to Frank Kuestner, of West Bethlehem, Pa., exploded on October 14th, blowing up the incubator, and, as one account puts it, "making a fearful mess." Five thousand eggs were smashed, and two hundred small chickens were killed. The cellar in which the boiler stood was also badly damaged.

(262.) — On October 15th, a boiler exploded in Henry Wadsworth's saw-mill, at Palestine, near Greenville, Ohio. James Howard and Washington Stover were instantly killed.

(263.) — A boiler exploded on October 17th in Julius Peters' saw-mill, eight miles southeast of Carrollton, Mo. Albert Peters, the eleven-year-old son of the proprietor, was blown about fifty feet, and sustained injuries from which he will die. Julius Peters was badly cut and bruised about the face, and will lose the sight of one of his eyes. Eben Webb and Joseph Barker were also injured, but to a lesser extent. The mill was entirely destroyed.

(264.) — A boiler exploded on October 17th, in the rear of the "Exchange," one of the leading hotels in Montgomery, Ala., while most of the guests were at supper. The electric light plant, the laundry, and the entire rear portion of the hotel were destroyed, and every house in town was shaken up. The hotel was instantly enveloped in darkness, and a panic followed, the women and children screaming and falling down the stairways. When matters had straightened themselves out it was found that nobody was killed. Four laundresses were injured, but none of them fatally so. Mr. O. L. Folds, the engineer, was struck on the head by a piece of scantling, but was not seriously hurt. The explosion was compared, by a local journalist, to "a reduced, but none the less frightful, reproduction of the last days of Pompeii." The loss is estimated at from $10,000 to $12,000.

(265.) — On October 17th, a fire occurred at the Juniata Sand Company's works, at Huntingdon, Pa., and during the course of it two of the boilers exploded. The plant was completely destroyed, and the machinery ruined. The damage is estimated at from $10,000 to $12,000; but we have seen no estimate of the proportion of this which was due to the explosion alone.

(266.) — A boiler exploded, on October 17th, at Haley's mill, near Spottsylvania Courthouse, Va. One man received severe injuries, from the effects of which he will die. Another man was also injured to a lesser extent, and will recover. The mill was destroyed.

(267.) — A boiler exploded at N. K. Dillard's mill, near Paris, Texas, on October 18th, instantly killing George Johnson (the engineer), and fatally injuring J. W. Jackman and three others. Eight men also received severe injuries, from which, however, they are expected to recover. The mill was entirely demolished, and the remains of the boiler were found hundreds of yards away.

(268.) — George Jackson was seriously scalded and cut, on October 18th, by the explosion of a boiler at George Boehner's slaughter-house, at Springfield, Ill. We did not learn the extent of the property damage.

(269.) — An oil-well boiler on the J. I. Collin's lease, at Wingston, near Bowling Green, O., exploded with terrible effect on October 20th. Henry Baker, the pumper, was found dead, several rods away. The boiler-house was completely shattered and strewn nearly all over a ten-acre lot.

(270.) — On October 21st, while a gang of men was at work repairing a high-pressure steam pipe connecting two batteries of boilers (twenty-two in all) at the American Wire Nail Works, Anderson, Ind., the pipe burst. Abraham Delcamp and Michael McNair were fearfully bruised and burned, and cannot live. Robert Bissell, Thomas Finden, George Hallis, John Jones, Edward Kieser, Henry Myers, James Rodgers, A. J. Sheets, and Henry Wycroff, were also severely injured, but at last accounts it was not thought that any of them would die. Part of the building in which the explosion occurred was blown down.

(271.) — On October 21st, a boiler flue collapsed in the basement of the Conservatory of Music, at Denver, Col. We did not learn of any personal injuries. [See also explosion No. 274, below.]

(272.) — A boiler exploded, on October 22d, in Holmes & Coleman's fence-picket mill, at Lomax, Ill. The mill had been shut down for an hour, and most of the men had gone away. John Holmes, one of the proprietors, was instantly killed, his body being blown fifty feet, and mutilated almost past recognition. Joseph White was also crushed and scalded, so that he was dead when found. L. B. Coleman and A. S. McGee were fearfully injured, but will recover. The mill was two stories high, and covered a considerable area. It was demolished so completely that hardly anything was left standing.

(273.) — The boiler of an engine used in sinking a well at the new county infirmary, two miles south of Warsaw, Ind., exploded on October 22d, killing the engineer and badly scalding one of the patients. The cell-house was also damaged to some extent. The explosion occurred while most of the workmen were at breakfast.

(274.) — While testing a boiler used for heating purposes in the basement of the Conservatory of Music, in Denver, Col., on October 22d, three men narrowly escaped death. They had been replacing a flue that had failed the day before, and when the work was completed it was decided to test the job under a steam pressure of 25 pounds. The new flue stood the test, but an old one, next to it, collapsed, and the basement was instantly filled with scalding steam. Andrew Blair and Roy C. Howell were severely burned. Blair was firing at the time, and his injuries are so serious that it is feared that he may not recover.

(275.) — The boiler of a traction engine exploded, on October 23d, at Helmer, near Butler, Ind. George Cowen and Henry Ballerck were injured so badly that they cannot live.

(276.) — A boiler exploded on October 24th, in Arbuckle & Coberly's mill, at London, Ohio. W. S. Coberly was terribly scalded about the head, face, and arms, and Perry Justice was bruised and scalded so badly that his recovery is doubtful. A young man named Roberts was also badly burned.

(277.) — On October 25th, a tube failed in a boiler at the Akron rolling mill, Akron, Ohio. Gustav Emmel, who was firing the boiler, was terribly scalded and burned. It is thought that he may die, though there are hopes of his recovery.

(278.) — Two boilers exploded on October 26th, in the Pacific Coast Mill, at Fairhaven, Wash. Fireman Thomas Armstrong and watchman J. Whitmore were killed instantly, and T. A. Bennett, G. W. Newkirk, G. T. Lewis, and G. W. Lindley, were injured more or less seriously. Newkirk's injuries are so severe that his physician says he cannot recover. The mill was destroyed. The estimates of the property loss are very various. The Seattle *Times* places it at $15,000.

(279.) — On October 26th, a boiler exploded on the tug *T. T. Morford*, at Chicago, Ill. The *Morford* was wrecked, and sank immediately. The pilot-house of the *O. B. Green*; another tug which was alongside of the *Morford*, was also blown off. Captain John Ferguson, master of the *Green*, and John Erickson, fireman on the *Morford*, were killed outright, and Charles Dick, engineer on the *Morford*, was fearfully injured, so that he died within a few hours at the hospital. Captain John Cullinan (of the *Morford*) and Lineman Daniel McRae were burned and otherwise injured, but will recover. At last accounts Erickson's body had not been found, although the river had been dragged for it.

(280.) — The boiler of a portable wood-sawing machine exploded on October 27th, at Wausau, near Milwaukee, Wis. Nobody was near it at the time.

(281.) — A boiler used to operate Frank Hafer's stone-crusher, exploded on October 28th, at the Shippensburg Normal School, near Chambersburg, Pa. We could not learn the particulars, except that nobody was hurt.

(282.) — A small boiler in the rear of Abraham Salisbury's elevator at Milwaukee, Wis., exploded on October 28th. The roof of the building in which the boiler stood was blown off, but the damage was small, and nobody was injured.

(283.) — A boiler exploded on October 29th, in the Lagonda Hotel, at Springfield, Ohio. Live coals were scattered everywhere, and a fire followed. The total damage, due to the explosion and the consequent fire, was about $50,000.

(284.) — A portable boiler exploded on October 30th, about two miles north of Port Washington, Ohio. Raymond Best was injured so badly that he died within a short time. His brother also received lesser injuries.

(285.) — A flue collapsed on October 30th, in the boiler of the old "Diamond Jo" Mississippi river packet *Libbie Conger*, as she was passing the mouth of Duck Creek, near Davenport, Iowa. Christopher Batalia was blown overboard and was drowned.

(286.) — A boiler exploded in Stedman's mills, near London, Ky., on October 30th, killing Matthew S. Herndon and a boy named Fields, and fatally injuring two other men.

(287.) — A boiler in the Edison Electric Light station, at Cincinnati, Ohio, exploded on October 31st, doing considerable damage. Several workmen narrowly escaped being scalded to death by the escaping steam.

The Variation of Latitude.

The astronomical world has been extremely interested, for the past few years, in the question of the fixity of the earth's axis of rotation. Of course it has long been known that this axis gradually changes its direction in space, owing to the attraction of the sun and moon upon what is called the "equatorial bulge" of the earth,— the "bulge" in question consisting of that part of the earth which lies outside of an imaginary sphere whose center is at the earth's center, and whose radius is such that the imaginary sphere coincides with the earth's actual surface at the north and south poles, but lies *inside* of that surface everywhere else. This motion of the axis is discussed in all the books on astronomy, and has been known for many years; but it is characterized by the important fact that as the *axis* slowly swings around, *the earth swings with it*, in such a way that if a stake were driven into the ground at the true north pole at any given instant, the point so fixed would always *continue* to be the true north pole. It has now been discovered that there is another and very different kind of motion, not previously known (although *suspected*, a long time ago); and the honor of discovering it belongs to an American astronomer, Dr. S. C. Chandler, of Harvard University. He has found that the axis about which the earth rotates preserves its direction in space (subject to the very slow motions of precession and nutation, referred to above), but that the earth itself shifts about uneasily, but in a regular way, so that the imaginary stake that we have conceived to be driven at the north pole at some given instant would not remain coincident with the axis of rotation. Relatively to the earth, the axis of rotation would describe a sort of curve about the stake. The motion is indeed slight, for the stake, if once coincident with the true pole, could never depart more than fifty-three feet from it, and could not go so far away as that, unless it were driven at a specially selected instant; yet, slight as this motion is, it is quite large enough to be noticeable in the refined astronomical work of to-day. The chief effect produced by the newly-discovered motion is to cause a variation in the latitude of all places on the earth's surface; for, owing to the shifting of the earth, any given spot is sometimes nearer the pole than its average distance, and sometimes further away. This leads to a wonderful and widespread complication, when we contemplate the accurate astronomical and geodetical measurements that have been made in the past. All of these measures, that involve a knowledge of latitude, will have to be corrected. The task thus brought to view is almost hopeless, and yet in some cases in which the corrections have been applied, it has been found that work which had yielded results apparently poor, or absurd, was really excellent, and very accurate. As a single instance of this, we may mention the work done by Professor Asaph Hall in determining the parallax of the star Vega. The result that he obtained, after an enormous amount of labor with the big telescope at Washington, was that the parallax of the star is *negative*; — a result which is quite preposterous, because, if it had any meaning at all, it could only mean that Vega is *more than an infinite distance* away, which is highly absurd. When the corrections that Dr. Chandler's researches indicated to be necessary had been applied to the observations, it was found that there was no longer any absurdity in the result, but that the observations were highly accurate, and that they gave a real and reasonable value of the parallax of the star. We append an article from the *Scientific American*, in which this subject is further discussed, in a popular way:

"It will now and then happen to the seeker after knowledge that he will have to unlearn as well as to learn; but it will be a rare experience for him to have to call in question such a supposedly fundamental truth as that of the invariability of terrestrial latitude. If there is one fragment more than another of our childhood's 'geography lesson' that abides ever with us, it is this: that 'the earth turns upon its axis.' And now we are told that it does not, and that, as a consequence, it is literally true that the parallels of latitude are perpetually shifting — not much, it is true; but sufficiently to make it comically possible, as was once suggested, that certain dwellers in the proximity of the Canadian border line never know for more than six months together in which country they live. The axis of the earth, or, to speak more accurately, the axis of the earth's figure, is an imaginary line, passing through the center of the earth, and terminating at its two flattest points, known as the North and South Poles. Up to the year 1888, it was supposed that the earth rotated about this axis. If this had been true, the latitude of any given spot, as determined by observation, should have been invariable. As a matter of fact, it had been noticed, even as far back as the last century, that there was a slight, but perceptible, variation. The latitude of a given spot, as shown by two observations taken at different times, was found to vary. Between the years 1884 and 1888, Dr. S. C. Chandler gathered together all the observations that had from time to time been made, and, after a careful analysis, was able to prove that these variations are accounted for by the fact that the earth does not rotate about its axis of figure, as above described, but about another axis, which he called the axis of rotation. This axis of rotation bisects the axis of figure at its center, and always preserves the same direction in *space* (except for the extremely slow motions of nutation and precession, as explained above); but, relatively to the earth, the axis of rotation slowly describes a sort of curve about the poles of the axis of figure. From this consideration it is evident that the equator of the earth's figure, and the small circles parallel to it, do not preserve the same planes relatively to space, but that they have an oscillatory motion. Hence the variation in latitude. [Here follows, in the original, a comparison of the earth's motion with that of a top; the comparison is omitted because it is not accurate.] The motion of the axis of rotation about the axis of figure is not very simple, being made up of two superposed motions. The pole of the axis of rotation moves in a small circle which is itself moving around the pole of the axis of figure. The period in which the small circle is described is between 423 and 434 days; and the center of this circle makes a circuit about the pole of figure in from 361 to 369½ days. The radius of the circle is fourteen feet, and its center travels in an ellipse, the major axis of which is twenty-five feet, and the minor axis about eight feet. A remarkable verification of Dr. Chandler's discovery was afforded by a series of tidal observations extending over thirty-five years, some of which were taken on the Pacific Coast and some on the Atlantic. These show a mean time of oscillation of the sea's level of about 431 days, which agrees remarkably well with the period of revolution as mentioned above. Newcomb had pointed out that if the theory of the revolution of the axis of rotation were true, low tide at any spot should occur when the pole of rotation lay nearest that spot — a suggestion with which the above-mentioned tidal observations fully agree."

The Locomotive.

HARTFORD, DECEMBER 15, 1895.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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OUR esteemed contemporary, the Denver *News*, indulges in a little rather grisly humor in connection with explosion No. 274, in the list published this month. It begins its account with a heading, in scare type, which reads : NINE LIVES WIPED OUT! But it presently appears that a black cat was the only creature killed outright, and that the scare-line was merely a playful allusion to the extraordinary vitality that fable says all pussies have.

THE end of the year being now at hand, with Christmas and its festivities in view, we desire to make our customary announcement that the index and title-page to THE LOCOMOTIVE for the current year will be ready shortly. They will be sent on request to any of our readers who have preserved their copies, and wish to bind them. The bound volumes for 1895 will also be ready in January, and may be had at the usual price of $1.00 each, postpaid.

NUMBER 270, in our list of explosions for October, printed in this issue, affords one more fearful object lesson, illustrating the danger of attempting to repair pipes, valves, or boilers, while they are under steam. This time two men were killed, and nine others received terrible injuries. We wish these frightful examples could educate all engineers, boiler-makers, and pipe-fitters, so that they might all see the foolhardiness of the thing ; but we are afraid that the old dogs will refuse to learn new tricks, no matter how gruesome the instruction ; and we suppose that similar accidents will continue to occur, with about the usual frequency.

The Secrets of Ashes.

The plant world presents many curious phenomena, which excite the student's curiosity and stimulate his imagination. Some of these phenomena are obscure, and have to be diligently sought for; while others stare us in the face, and are, in fact, so *familiar* that they do not receive the attention they deserve, until some unusually observant person calls attention to them. Some of the more unobtrusive of these mysteries are brought before us by a study of so homely a material as the *ashes* that remain after plants have been burned.

It is well known that the great majority of the more familiar plants obtain their nutriment partly from the air, and partly from the soil. Some, it is true — as in the case of the curious epiphytes, or air plants, that grow in hot countries — obtain all their substance from the air; while others, such as sea-weeds (which have no true roots), absorb everything they need from the water in which they are submerged. Confining our attention to the more familiar land plants, however, we may say that there are, in general, two sources from which the supplies required for their growth are obtained. Carbon, for example, is believed to be drawn exclusively from the air; the leaves of the plant absorbing the carbonic acid that is always present in a certain small proportion, splitting it up into its constituent parts — oxygen and carbon — retaining the solid carbon, and pouring the gaseous oxygen back into the air. It is quite probable that the traces of ammonia that are present may also be absorbed by the leaves, the nitrogen of the ammonia being also used for the purposes of growth. The minor solid components of plants — the lime, magnesia, potash, silica, phosphorus, iron, etc., — are absorbed from the soil by the roots, and carried up to the leaves through the stem.

If a plant be dried and then burned, all the gaseous and volatile constituents pass away in smoke, and that which is left behind — the ash, namely, — represents, for the most part, the solid matter which has been absorbed by the roots. A study of the composition of the solid matter thus absorbed reveals many interesting and wonderful things, a few of which we are about to suggest. (For the data presented below we are indebted to Professor Kerner's wonderful work on the *Natural History of Plants*, which is now available to American and English readers through Professor Oliver's most excellent translation.)

The first thing that strikes us, upon examining a plant ash, is that the solid matters that are taken up by the roots are not absorbed in anything like the proportions in which they occur in the soil. In fact, it seems almost as though the rootlets were intelligent chemists, recognizing each substance that they touch, and knowing what quantity of it is required by the plant above. This is well illustrated by the analysis of the ashes of different plants growing side by side, in the same soil. Thus Kerner gives four such analyses, made on specimens of (1) the water-soldier (*Stratitoes aloides*), (2) the white water-lily (*Nymphæa alba*), (3) a stone-wort (*Chara fœtida*), and (4) a reed (*Phragmites communis*). The results, so far as potash, soda, lime, and silica are concerned, are as follows:

RESULTS OF ANALYSES OF PLANT-ASHES.

Substance Found.	Plant Examined.			
	Water-soldier.	Water-lily.	Stone-wort.	Reed.
Potash,	30.8	14.4	0.2	8.6
Soda,	2.7	29.7	0.1	0.4
Lime,	10.7	18.9	54.8	5.9
Silicic Acid,	1.8	0.5	0.3	71.5

When it is remembered that these four plants all grew close together, and that the soil from which their supplies were drawn was identical, so far as could be discovered, the results here given are truly wonderful. The stone-wort, it will be seen, contained a very large quantity of lime, and barely a trace of potash, soda, or silica; while nearly *three-quarters* of the ash of the reed consisted of silica, and there was less than one-ninth as much lime as was found in the stone-wort.

If we pass from the consideration of different plants growing in the same soil, to that of the same plant growing in different soils, the results are equally wonderful. Thus Kerner gives analyses of the ash obtained from the foliage and branches of the yew-tree (*Taxus baccata*), the specimens analyzed being taken from soils rich in serpentine, limestone, and gneiss, respectively. The results are presented in the accompanying table. It will be seen that there are some slight difference in composition, but when the wide difference in the soils is taken into account, it is remarkable that the proportions are so nearly alike.

ANALYSES OF THE ASH OF THE YEW-TREE.

Substance Found.	Nature of Soil.		
	Serpentine.	Limestone.	Gneiss.
Silicic Acid,	3.8	3.6	3.7
Sulphuric Acid,	1.9	1.6	1.9
Phosphoric Acid,	8.3	5.5	4.2
Iron Oxide,	2.1	1.7	0.6
Lime and Magnesia,	38.8	41.2	36.3
Potash,	29.6	21.8	27.6
Carbonic Acid,	14.1	23.1	24.4

One feature that was prominent in the analyses of the yew-tree ash has been purposely obscured in the table by counting the lime and magnesia *together*. It appears that when a plant needs a certain substance for its growth, it will sometimes make use of some other substance, *whose chemical properties are closely similar*, provided the more desirable one cannot be had in sufficient quantities. Thus the ash of the yew-trees growing over limestone contained 36.1 per cent. of lime, and 5.1 per cent. of magnesia; and that of the trees growing over gneiss contained 30.6 per cent. of lime and 5.7 per cent. of magnesia. The serpentine soil, however, was much poorer in lime than either of the others — serpentine being composed almost entirely of silica and magnesium — and the trees growing upon this soil, being unable to obtain the necessary quantity of *lime*, accepted, in the place of the lime, an equal weight of *magnesia*, a substance strongly resembling lime in its chemical properties; the observed quantity of lime in these trees being only 16.1 per cent., while magnesia was present to the extent of 22.7 per cent. This peculiarity reminds one of the experiments that were tried, some few years ago, to find out whether hens could construct egg-shells of anything except lime. The hens upon which the experiment was tried were fed upon materials from which lime was carefully excluded, until they began to lay eggs entirely devoid of shells. They were then allowed reasonable rations of various salts of barium — a body closely resembling calcium, which is the basis of lime. The results were negative. No shells appeared, whatever the compound of barium that was supplied. It was found, however, that *any* compound of lime would do, it being apparently a matter of indifference to the hen whether she was fed on the sulphate, carbonate, phosphate, or any other salt of calcium, that she could eat without discomfort. Any compound of lime would yield shells, but no compound of barium would do it. We wish somebody would try that same experiment, substituting *magnesia* for lime, so that we might know whether the yew-tree has a more catholic taste than the hen, or not.

Another thing that plant-ashes reveal is that plants often possess a most amazing power of collecting large quantities of a particular substance that they may happen to need, even when this substance is present in the soil or the water in which they are growing, in such extremely minute quantities that it can barely be detected there by the most delicate chemical tests that we possess. For example, certain kinds of saxifrages, when growing upon a substratum of quartz and slate, frequently collect so much carbonate of lime that this substance forms a marked incrustation on the edges of the leaves, even though no trace of lime can be found in the soil in which they are growing, nor in the rocks beneath it, except in the little scales of mica that occur here and there, but which are not easily decomposable. Another case of this sort, more remarkable still, is afforded by the white water-lily mentioned in the first table. It will be noticed that this plant contains a large proportion of soda — this body forming, in fact, almost one-third of the total weight of the ash. The soda thus found is present in the plant as sodium chloride; — that is, in the form of common salt. It might be inferred that the water in which it grew was brackish; but this was not the case. A careful analysis of the water revealed the presence of only about one-third of one per cent. of salt, and the earth in which the roots of the plant were fixed contained *only one one-hundredth of one per cent.* of that substance! Another instance of the same general character is afforded by the sea-weeds of the North Sea, which are so rich in iodine that they formed the chief source of this substance for many years, in fact, until the extensive South American deposits of sodium iodide were discovered, a few years ago. One would naturally infer that the sea-water in that part of the world would contain considerable quantities of iodine, or, at least, of soluble iodides; and yet the fact is, that nobody has yet succeeded, by the most delicate tests, in discovering any trace of it. Such a fact as this indeed suggests the possibility that iodine is not an element, but that it is constructed, by the sea-weeds that contain it, out of the chlorine that the sea contains in abundance. (Iodine and chlorine are certainly very similar in their chemical relations, but the hypothesis here put forward is, of course, the merest conjecture.)

One more fact relating to the marvelous power of selection that plants sometimes exhibit must close our list. This time we are concerned with the tiny little things called diatoms, which construct for themselves the beautiful shells of silica that affords microscopists so much delight. One would certainly think that these quartz-like shells could not be constructed unless silica were present in large amounts; but here is what Kerner says of a case which came under his observation: "Above the Arzler Alp, in the Solstein chain near Innsbruck, there is a spring of cold water which falls in little cascades between blocks of rock. The water of this spring is hard, and it deposits lime at a little distance from the source. Exactly at the spot where it wells out of a fissure in the rock its bed is entirely filled by a dark-brown flocculent mass which consists of millions of cells of the beautiful *odontidium hiemale*, a species of diatom with siliceous coating. These cells are ranged together in long rows, and are present in numbers and luxuriance such as are scarcely ever to be observed in other situations. Yet the spring water flowing round contains so little silicic acid that no trace of this substance can be discovered in the residue from the evaporation of 10 liters [over two gallons and a half]."

No adequate explanation of the marvelous selective power of plants has been given. In fact, it is doubtful if we yet know enough of the actual facts to frame a rational theory to account for them; but we have learned enough, at all events, to cause us to respect them, profoundly, in their capacity as *analytical chemists.*